DOCUMENT RESUME

ED 273 752	CE 044 877

TITLE	Environmental Support Specialist. J3ABR56631
INSTITUTION	Air Force Training Command, Sheppard AFB, Tex.
PUB DATE	86
NOTE	923p.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052) -- Guides - Classroom Use - Materials (For Learner) (051)
EDRS PRICE	MF06/PC37 Plus Postage.
DESCRIPTORS	Conservation (Environment); Course Content; Environmental Education; Environmental Standards; *Environmental Technicians; *Job Skills; Lesson Plans; Military Personnel; *Military Training; Occupational Safety and Health; Postsecondary Education; Units of Study; Utilities; Waste Disposal; *Waste Water; Water Pollution; Water Quality; *Water Resources; *Water Treatment
IDENTIFIERS	Air Force; Military Curriculum Materials

ABSTRACT

This document package contains an Air Force course used to train environmental support specialists. The course is organized in four blocks of instruction covering 320 hours (or eight weeks), and is designed for group instruction. The four blocks cover the following topics: environmental fundamentals and support equipment, water and wastewater analysis, water supplies and treatment, and wastewater treatment and disposal. The following materials are included in the package: plan of instruction (lesson plans) for the instructor, student study guides/workbooks for each block of the course, progress checks (tests and performance demonstrations), and some background material on basic physics. Student study guides contain objectives, information, exercises, summary, and references for each of the lessons in the course. Materials are illustrated with line drawings. (KC)

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ENVIRONMENTAL SUPPORT SPECIALIST

J3ABR56631

SHEPPARD
TECHNICAL TRAINING CENTER

UNITED STATES AIR FORCE

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CHANGE NOTICE

POI J3ABR56631 000
(PDS Code AWT)

PLAN OF INSTRUCTION
(Technical Training)

ENVIRONMENTAL SUPPORT SPECIALIST

4 June 1984

SHEPPARD TECHNICAL TRAINING CENTER

4 June 1984 - Effective 22 August 1984 with Class 840822

Changed 4 November 1985 - Effective 13 February 1986 with class 860213
Changed 12 May 1986 - Effective 8 July 1986 with class 860708

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DEPARTMENT OF THE AIR FORCE
USAF TECHNICAL TRAINING SCHOOL (ATC)
SHEPPARD AIR FORCE BASE, TEXAS 76311

PLAN OF INSTRUCTION J3ABR56631 000
(PDS Code AWT)
4 June 1984

FOREWORD

1. PURPOSE: This publication is the plan of instruction (POI) when the pages listed on page A are bound into a single volume. When separated into units of instruction, it becomes the lesson plan/part I. The POI contains the qualitative requirements for course J3ABR56631 000, Environmental Support Specialist, in terms of objectives for each unit of instruction and shows planned time, training standard correlation, and support materials and guidance. This POI was developed according to ATC 52-18.

2. COURSE DESIGN/DESCRIPTION: The instructional design for this course is Group/Lock Step. This course trains airmen to perform duties prescribed in AFR 39-1 for Apprentice Environmental Support Specialist, AFSC 56631. Training included an introduction to water and wastewater processing, instruction in water and wastewater analysis, operating principles of water treatment plants, operating principles of wastewater treatment plants, and maintenance of water and waste processing system components. In addition, military training on traffic safety education, commander's calls and physical conditioning.

3. REFERENCES: This POI is based on Specialist Training Standard, 566X1, Feb 79 and Course Chart J3ABR56631 000, 7 Jun 83.

4. Deviation from the sequence of instruction listed in this POI is authorized when it is necessary to minimize the detrimental effect of adverse weather, inoperative equipment, or other factors of temporary duration which would otherwise cause training deficiencies.

DAVID K. JACKSON, Colonel, USAF
Commander, 3770 Technical Training Group

Supersedes POI J3ABR56631, 9 February 1983
OPR: Electrical Branch
Prepared by: James W. Phillips
DISTRIBUTION: Listed on Page A

J3ABR56631 000, 4 June 1984 is changed as follows:

1. Remove replaced or deleted pages and insert changed and new pages according to listing on page A.

2. The asterisk (*) indicates that the page is a replacement or addition or has been changed by this change notice.

William W. Miller
WILLIAM W. MILLER, Col, USAF
Commander 3770 Technical Training Group

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE

Environmental Fundamentals and Support Equipment

1. COURSE CONTENT	2. TIME

1. Course Orientation — 2 Day 1 (2)

   a. Welcome

   b. TDY Student Processing

      (1) Necessity of clearing through in-processing

      (2) Instructions for completion of STTC Form 120

      (3) Attendance is mandatory unless officially excused

      (4) Student departure from training for personal reasons: A TDY military or civilian student who abandons his or her training mission prior to completion, for personal reasons, will be responsible for part or all of the travel and living expenses. (Ref: Joint Travel Regulations, paragraph C4464 for civilian personnel and the Comptroller General Decision, 49 Comp Gen 663, for military members.)

   c. Overview of Course Content and Administration

   d. Types, Use, and Care of Training Literature

   e. Effective Study Techniques

   f. Benefits of Community College of the Air Force

   g. Exercises, General Safety, and Conservation While in the Training Areas

   h. Branch/Course:

      (1) Policies and directives pertinent to attendance in technical training courses.

      (2) Contact who will assist the student in resolving problems during duty hours.

      (3) What is expected of students in school.

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(4) School schedules.

(5) School grading; student testing, progress checks, and student recognition program

(6) Washback, proficiency advancement, special individual assistance, counseling and elimination.

(7) Proper dress and personal appearance while in training areas.

i. Student Critique Program

j. Fraud, Waste and Abuse

k. Sexual Harassment

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-I-1, Course Orientation
ATC PT 52-11, Study Skills

Training Methods

Lecture/Discussion	(1.5 hrs)
Performance	(.5 hr)

Instructional Guidance
Welcome the students to the course. Begin orientation and distribute SW, WB and PT. Explain the course and class name and number. Give an overview of the course and explain what is taught in each area. Have the students complete orientation exercise. Show students the fire exits, break areas, tornado shelter, latrines and immediate course areas.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Environmental Fundamentals and Support Equipment

1. COURSE CONTENT	2. TIME
2. Career Ladder	2
a. Given an extract from AFR 39-1, select information that describes the duties and responsibilities of the 566X1 Career Field. Four of the five must be correct. STS: 1b MEAS: PC (1) Specialty Summary (2) Duties and Responsibilities (3) Qualifications	(1)
b. Using the 566X1 career field ladder, list the AFSC titles and the methods of advancing from one step to another. Ten of fourteen must be correct. STS: 1a MEAS: PC (1) AFS code digits (2) Steps of an AFSC ladder (3) Methods of upgrading from one step to another	(1)

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-I-2, Career Ladder
Audio Visual Aids
Training Film: FLC 7/100, The Gifts

Training Methods
Lecture/Discussion (1 hr)
Performance (1 hr)

Instructional Guidance
Show film, The Gifts, before starting first objective. Discuss the duties and responsibilities as described in AFR 39-1. Discuss the digits that make up an AFSC. Present an AFSC ladder and discuss how each step may be obtained. Discuss the training required to progress through the career field. Use progress checklist to evaluate students.

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PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Environmental Fundamentals and Support Equipment

1. COURSE CONTENT	2. TIME

3. Civil Engineering Management 3

a. Given four statements, select the one that best identifies the BCE mission. STS: 5a MEAS: PC (.25)

(1) Mission of CE Units

(2) PRIME BEEF

(3) RED HORSE

b. Given an incomplete BCE organizational structure chart, complete the chart by writing the names of the missing functional areas in the appropriate spaces. Three of five must be correct. STS: 5a MEAS: PC (1)

(1) Branches

(2) Sections

(3) Units

(.75)

c. Using a representative list of functions, responsibilities and a list of CE units, match the functions and responsibilities to the CE unit to which they apply. Six of nine must be correct. STS: 5b MEAS: PC

(1) Functions and responsibilities

(2) Units

d. Define property accountability and responsiblity. STS: 5c MEAS: PC (1)

(1) Pecuniary liability

(2) Custodial responsibility

(3) Property accountability

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-I-3, Civil Engineering Management

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Training Methods

Lecture/Discussion (1.5 hrs)
Performance (1.5 hrs)

Instructional Guidance

Discuss the Base Civil Engineering organizational structure, policy, and function. Discuss the pecuniary liabilities, property accountability and custodial responsibilities of Air Force personnel. Complete PC J3ABR56631 000-I-3a, b, c, d. Use progress checklist to evaluate students.

Instructional Reference Material

AFR 67-10, Responsibility for Management of Public Property in Possession of the Air Force
AFR 85-10, Operation and Maintenance of Real Property

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Environmental Support Specialist

BLOCK TITLE
Environmental Fundamentals and Support Equipment

1. COURSE CONTENT	2. TIME
4. Security (OPSEC)	1
a. Given information pertaining to the operational activities related to AFSC 566X1, select three activities which indicate OPSEC vulnerabilities. STS: 2f MEAS: PC	(1)

(1) Secure areas

(2) Contingency operations

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-I-4, Security (OPSEC)

Training Methods
Lecture/Discussion (.5 hr)
Performance (.5 hr)

Instructional Guidance
Discuss the vulnerabilities of the Environmental Support Career Field to possible OPSEC violations and have students complete Progress Check J3ABR56631 000-I-4a, Vulnerabilities of AFSC 56631 to OPSEC Violations. Use progress checklist to evaluate students.

SUPERVISOR APPROVAL OF LESSON PLAN

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PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Environmental Fundamentals and Support Equipment

1. COURSE CONTENT	2. TIME

5. Technical Publications 6

Day 2

a. Use numerical indexes and requirement tables, locate the title of a manual, a regulation and a technical order when the numbers are known, with no more than three instructor assists. STS: 3a MEAS: PC (2)

(1) Purpose of technical publications

(2) Types of technical publications

(3) Identification of indexes

(4) How to use the indexes

b. Using a manual, a regulation, a technical order and a commercial publication, find the answer to a given problem with no more than three instructor assists. STS: 3b, 5h MEAS: PC (2)

(1) Proper use of technical publications

(2) Identification of equipment and units

(3) Maintain commercial publication file

c. Given information pertaining to a technical order deficiency, select the action that should be taken to correct the deficiency. Three of the four must be correct. STS: 3d MEAS: PC (1)

(1) Who is responsible for reporting technical order deficiencies

(2) AFTO Form 22

d. Using the parts of a GSA supply catalog and an incomplete list of stock numbers and nomenclatures, locate and list the missing information with no more than two instructor assists. STS: 3c MEAS: PC (1)

(1) Purpose and advantages of supply catalog

(2) Parts of a supply catalog

SUPERVISOR APPROVAL OF LESSON PLAN

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(3) How to use a supply catalog

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

SG AFS 53, 54, 55, 56, Publications
AFR 0-1, Numerical Index of Standard and Recurring Air Force Publications
AFR 39-1, Airman Classification Regulation
AFR 91-26, Maintenance and Operation of Water Supply, Treatment and Distribution Systems
AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems
TO 0-1-01, Numerical Index, Alphabetical Index Cross-Reference Table
TO 0-1-02, General Technical Order
TO 00-5-1, Technical Order System
TO 00-5-2, Technical Order Distribution System
TO 40W4-9-1, Operator and Organizational Maintenance Manual WPU Trailer Mounted 600GPH
TO 40W4-9-14, Organizational Maintenance Repair Parts and Special Tool Lists,
TO 40W4-13-1, Water Purification Unit, Reverse Osmosis 600GPH Trailer Mounted
AFTO Form 22, Technical Order System Publications Improvement Report and Reply
GSA Catalog

Training Methods

Lecture/Discussion	(3.0 hrs)
Performance	(3.0 hrs)

Instructional Guidance

Discuss the TO system and how to identify and use the indexes. Assist students in locating publication information pertaining to Progress Checks. Explain the Air Force regulation and manual system and how to use Air Force Regulation 0-2. Explain the purpose and use of regulations, manuals, and commercial publications. Explain the GSA catalogs and how to use them. Assign Progress Checks. Use progress checklist to evaluate student.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Environmental Fundamentals and Support Equipment

1. COURSE CONTENT	2. TIME
6. Safety Program and Accident Prevention	2
a. Identify two basic facts about the Air Force Safety and Accident Prevention Program. STS: 6a MEAS: PC	Day 3 (.5)
(1) Purpose of the safety program	
(2) Consequence of unsafe acts	
(3) Main points in the accident prevention program	
b. Given a list of shop and plant safety hazards, write the method of eliminating each hazard in accordance with Air Force directives with no more than one instructor assist. STS: 6b MEAS: PC	(1.5)
(1) General shop and plant safety hazards	
(2) Specific shop and plant safety hazards	
(3) The use of protective clothing and equipment	

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG AFS 54, 55, and 56, Safety, All Courses

Training Methods
Lecture/Discussion (1 hr)
Performance (1 hr)

Instructional Guidance
Explain the purpose and advantages of a good safety and accident prevention program. Discuss general ground safety and hazards in and around water and wastewater plants. Explain the proper care and utilization of shop tools and equipment. Emphasize the removal of all jewelry. Use progress checklist to evaluate students.

Instructor Reference Materials
AFR 91-26, Maintenance and Operation of Water Supply, Treatment and Distribution Systems
AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems.

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PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Environmental Fundamentals and Support Equipment

1. COURSE CONTENT	2. TIME

7. Corrosion Control 4 Day 3

a. Using information pertaining to corrosion, list the causes and the types of corrosion. Five of eight must be correct. STS: 5j MEAS: PC (2)

(1) Corrosion Process

(2) Types of Corrosion

b. Identify the three methods used to control the corrosion process. STS: 5j MEAS: PC (2)

(1) Design

(2) Cathodic Protection

(3) Protective Coating

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-I-7, Corrosion Control

Audio Visual Aids
Training Film: 28117, An Ounce of Prevention
Training Film: TF6142, Public Works Utility Corrosion Protection

Training Method

Lecture/Discussion	(3 hrs)
Performance	(1 hr)

Instructional Guidance
Discuss the factors and the types of corrosion and the methods of preventing corrosion. Name the types and explain the principles of operation of each type of cathodic protection. Emphasize the main points to look for in the training films. Show the training films. Have students complete the progress check. Use progress checklist to evaluate students.

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NAME OF INSTRUCTOR	COURSE TITLE Environmental Support Specialist

BLOCK TITLE
Environmental Fundamentals and Support Equipment

1. COURSE CONTENT	2. TIME
8. Hand and Special Tools	3

a. Given a list of tasks and a list of tools, select the tool that should be used to complete each task. STS: 7a MEAS: PC (1.5)

- (1) Types of common handtools
- (2) Uses of tools
- (3) Safety of tools
- (4) Care of tools
- (5) Tool inventory

b. Given an electric grinder, a checklist and handtools, perform the required inspection and maintenance on the grinder with no more than one instructor assist. STS: 7b MEAS: PC (1.5)

- (1) Inspection requirements
- (2) Maintenance requirements

* Physical Conditioning (1.0)

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-I-8, Hand and Special Tools

Audio Visual Aids
Training Film: TF 1-4603 ABCs of Handtools

Training Method
Lecture/Discussion (1.5 hrs)
Demonstration (.5 hr)
Performance (1.0 hr)

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Instructional Guidance

Identify and discuss common handtools, their purpose and the correct way to use them. Emphasize that there is a right tool for each job and you must use the right tool. Show the film and give a brief demonstration on how to use handtools using parts of the pump trainer as demonstration support equipment. Complete progress check on handtools. Stress safety when working with tools. Use progress checklist to evaluate students. The instructor will assist with the most difficult parts of the task.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Environmental Fundamentals and Support Equipment

1. COURSE CONTENT	2. TIME

9. Operation and Maintenance of Water and Wastewater Treatment Support Equipment — 38 Day 4

a. Given four control devices, identify, inspect, and state the function and operation of each. STS: 11a(5), 11b(5) MEAS: PC (2)

(1) Purpose of control devices

(2) Types of control devices

(3) Function and operation of control devices

(4) Preventative maintenance procedures

b. Identify the purpose, operating features and operator maintenance requirements for air compressors. Three of the five must be correct. STS: 11a(8), 11b(8) MEAS: PC (1)

(1) Purpose of air compressors

(2) Operating features

(3) Operator maintenance

c. Using AFR 91-26, list the purposes, types and inspection procedures for water storage tanks. STS: 11a(9), 11b(9) MEAS: PC (1)

(1) Purposes of storage

(2) Types of storage tanks

(3) Inspection of storage tanks

(1)

d. Given a set of incomplete statements about various valves, make written responses to identify each valve. Seven of the ten must be correct. STS: 11a(2) MEAS: PC

(1) Purpose of valves

(2) Types of valves

(3) Valve components

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e. Given a check valve, disassemble, inspect, and reassemble the valve with no more than one instructor assist. STS: 11b(2) MEAS: PC (1.5)

(1) Types of check valves

(2) Maintenance of check valves

f. Using a gate valve on the pump trainer, remove and replace the valve packing to prevent water leakage, with a maximum of two instructor assists. STS: 11b(2) MEAS: PC (1.5)

(1) Replace packing

(2) Maintenance

Day 5

g. Using AFR 91-26 and information pertaining to electric motors and power connectors, list the operational checks and operator maintenance requirements for the motors and connectors. STS: 6b, 7b, 11a(7), 11b(7) MEAS: PC (3)

(1) Operational checks

(2) Power connections

(3) Maintenance

h. Given information pertaining to chemical feeders, identify the three types of chemical feeders by completing written statements. STS: 11a(3)(a), 11a(3)(b), 11a(3)(c) MEAS: PC (1.5)

(1) Purpose of chemical feeders

(2) Types of chemical feeders

i. Given chemical feeders and working as a team. Perform the required maintenance on the chemical feeders with a maximum of five instructor assists. STS: 11b(3)(a), 11b(3)(b), 11b(3)(c) MEAS: PC (2.5)

(1) Safety precautions and tool selection

(2) Preventive maintenance

(3) Disassemble/Inspect/Reassemble

* Physical Conditioning (1)

j. Given information pertaining to different types of measuring devices, write the function and application of each and record a meter reading. Five of the seven must be correct STS: 11a(4) MEAS: PC Day 6 (1.5)

(1) Types of measuring devices

(2) Reading meters/recorders

k. Given a meter, disassemble, inspect and reassemble the meter using a checklist or manufacturer's brochure with no more than one instructor assist. STS: 11b(4) MEAS: PC (1.5)

(1) Servicing meters/recorders

(2) Disassembly/reassembly procedures

l. Monitor the operation of selected backflow preventers and list four methods of backflow prevention with no more than one instructor assist. STS: 12b(1) MEAS: PC (2)

(1) Backflow

(2) Cross connection

(3) Hazards

(4) Types of backflow preventers

m. Given four types of backflow preventer malfunctions, select the maintenance required to correct the malfunction. Three of four must be correct. STS: 12c(1) MEAS: PC (1.5)

(1) Operation

(2) Maintenace

n. Using AFR 91-26, list three operational services which are common to standby engines. STS: 11a(6), 11b(6) MEAS: PC (1.5)

(1) Use of standby engines

Day 7

(2) Operational checks

o. Given a list of pump types and a list of pump chacteristics, match the pump type to its chacteristic. Three of five answers must be correct. STS: 11a(1) MEAS: PC (3)

(1) Purpose of pumps

(2) Types of pumps

p. Using the sewage lift station trainer and working as a team, monitor/operate the trainer in accordance with standard operating procedures, with no more than two instructor assists. STS: 12d(1) 12d(2) MEAS: PC (3)

(1) Purpose of operation

(2) Principles of operation

(3) Types of lift stations

(4) Safety

(5) Operation of the trainer

q. Using the sewage lift station trainer, and working as a team, perform operator inspection and maintenance on the trainer in accordance with a checklist, with no more than two instructor assists. STS: 12d(3) MEAS: PC (2)

(1) Safety items

(2) Preoperation inspection

(3) Maintenance procedures

Day 8
(7)

*r. During a field trip to the base water and wastewater facilities, use a checklist to monitor and inspect the support equipment. Students checklist must correspond to 60% of instructor's evaluation of the facility. STS: 11a(1), 11a(2), 11a(3)(a), 11a(4), 11a(5), 11a(6), 11a(7), 11a(9), 11b(3)(a), 11b(3)(c), 11b(6), 11b(7), 11b(9) MEAS: PC

(1) Safety procautions to be observed

(2) Preview of water facility

(3) Preview of wastewater facility

(4) Monitor and inspect water treatment equipment

(5) Deficiencies noted and corrective actions recommended

(6) Monitor and inspect wastewater treatment equipment

(7) Deficiences noted and corrective action recommend.

* Physical Conditioning (1)

* In case of inclement weather or unavailability of transportation, the class schedule will be altered so that the field trip can be taken when weather moderates or transportation can be arranged.

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-I-9, Operation and Maintenance of Water and Wastewater Support Equipment

Training Equipment
Lift Station Trainer
Water Pump Trainer
Bench Items - control devices, water meters, valves, drive equipment
Gas Chemical Feeder and Trainer
Solution Feed Trainer

Audio Visual Aids
Training Film: 4682, Water, Water Everywhere

Training Methods

Lecture/Discussion	(14 hrs)
Demonstration	(4 hrs)
Performance	(20 hrs)

Instructional Guidance

Discuss and demonstrate the operation, service and adjustment of control devices. Distribute the devices among the students to view. Discuss and explain the types, purpose and maintenance procedures of air compressors, storage tanks, and the corrosion prevention of steel tanks. Show films about backflow prevention. Take the class to room 37 to monitor the operation of backflow preventors using the backflow trainer. Explain and discuss drive equipment, electric motors and the safety and maintenance requirements involved with each item. Show the available support and drive equipment to the students. Discuss and demonstrate the procedures and what to look for during an inspection of drive equipment and motors using the pump trainer. Explain the types, purpose and maintenance of chemical feeders, meters, and metering devices, recorders, valves, engines and pumps. Distribute the various visual aids to the students to enforce learning concept. Discuss the operational procedure of each. Have students perform on a chemical feeder, meter and valve. Explain and operate the sewage lift station trainer. Go on a field trip to the base water and wastewater facilities. Explain and discuss the plant components and support equipment. Have students complete the study guide/workbook and progress check while on the fieldtrip. Stress safety while operating the trainers and during the field trip include health hazards and personal hygiene. Use progress checklist to evaluate students when they complete workbooks.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Environmental Fundamentals and Support Equipment

1. COURSE CONTENT	2. TIME

10. Pump and Equipment Maintenance 13

Day 9

a. Given a centrifugal pump, and working as a team, disassemble, inspect and reassemble the pump with no more than two instructor assists. STS: 5h, 6b, 7a, 11a(1), 11b(1) MEAS: PC (6)

(1) Inventory and select the proper tools

(2) Pump disassembly

(3) Pump reassembly

b. Using the water (pump) trainer and working as a team, remove, disassemble, inspect, reassemble and install the pump to its operating condition with no more than two instructor assists. STS: 6b, 7a, 7b, 11a(1), 11b(1) MEAS: PC (2)

(1) Pump and Water Trainer

(2) Remove and disassemble pump

(3) Inspect

Day 10

b. Continued from Day 9 (5)

(4) Reassemble and install pump

(5) Operate pump trainer

(6) Tool inventory/clean area

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-I-10, Pump and Equipment Maintenance

Audio Visual Aids
Training Film: LFS 56/5 Centrifugal Pump Maintenance

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Training Equipment
Centrifugal Pumps
Handtools
Pump Trainer

Training Methods

Lecture/Discussion	(3 hrs)
Demonstration	(1 hr)
Performance	(9 hrs)

Multiple Instructor Requirements
Equipment and Facilities - 2

Instructional Guidance
Show the film on pump maintenance and repair. Divide the class into two groups of two students each and assign each group to a pump. Check the pump after disassembly to make sure all the parts are serviceable. Check the pump after reassembly to insure correct assembly and that the shaft turns freely. Have students remove the operating pump from the trainer and install the previously reassembled pump. Operate the pump and check for leaks; stop any leaks found. Use performance checklist to evaluate students.

MIR: The class is divided into six teams, two members each, during the pump performance projects. Two instructors are required to provide the teams with individual assistance and instructions while they work on the pumps. Continuous class supervision is required for each team to preclude damage to the equipment, correct procedures and safety factors.

11. Written Test and Test Critique (2)

* PHYSICAL CONDITIONING (1)

* DENOTES MT

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE

Water and Wastewater Analysis

1. COURSE CONTENT	2. TIME
1. Related Mathematics	10 Day 11
a. Solve problems in addition, subtraction, multiplication, and division of whole numbers. STS: 8a MEAS: PC	(1)
(1) Need for mathematics in the environmental support field	
(2) Review of arithmetic	
b. Solve problems in addition, subtraction, multiplication, and division of decimals. STS: 8a MEAS: PC	(1)
(1) Definition of a decimal	
(2) Reading decimals	
(3) Rules for working with decimals	
(4) Rounding off decimals	
c. Solve problems in addition, subtraction, multiplication, and division of fractions. STS: 8a MEAS: PC	(1.5)
(1) Definition of a fraction	
(2) Types of fraction	
(3) Reading fractions	
(4) Conversion of fractions to decimals	
(5) Conversion of decimals to fractions	
(6) Rules for solving problems	
d. Given the formulas, dimensions, and a geometric figure of a square, rectangle and circle, compute the area of each. STS: 8a MEAS: PC	(1.5)
(1) Computing the surface area of a square	
(2) Computing the surface area of a rectangle	

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(3) Computing the surface area of a circle

e. Given the formulas, dimensions and a geometric figure of a square, rectangle and cylinder, compute the volume of each. STS: 8a MEAS: PC (1.5)

(1) Computing the volume of a cube

(2) Computing the volume of a rectangle

(3) Computing the volume of a cylinder

(4) Computing the volume of a pool

f. Given problems pertaining to a typical water supply system and a maximum of three instructor assists, follow the correct procedures to complete each problem. STS: 8a MEAS: PC (1.5)

(1) PSI in a given container

(2) Pumping rate of a water pump

(3) Gallons of water in a given container

Day 12

(4) Weight of one gallon of water

(5) Chemical computation

g. Given the temperature conversion formulas, convert temperatures between the metric and English systems. STS: 8a MEAS: PC (2)

(1) Reason for conversion

(2) Temperature conversion

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-II-1, Related Mathematics

Training Methods
Lecture/Discussion (4 hrs)
Performance (6 hrs)

Instructional Guidance
Discuss the need for a refresher in basic mathematics, and explain typical examples or problems which are common to the water and wastewater field. Write examples on the chalkboard to enhance learning objectives. Have students complete progress check and evaluate on a progress checklist.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Water and Wastewater Analysis

1. COURSE CONTENT	2. TIME
2. Principles of Physics	4 Day 12 (4)

a. Using information and a list of eight incomplete statements concerning physics, complete the statements. Five of the eight statements must be correct. STS: 8b(2) MEAS: PC

(1) Define physics

(2) Energy

(3) Matter

(4) Structure of matter

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-II-2, Principles of Physics

2TPT5120-03, Basic Physics-Matter

Training Methods
Lecture/Discussion (2 hrs)
Performance (2 hrs)

Instructional Guidance
Discuss the principles of physics and emphasize the importance of physics in the 566X1 career field. Assign and monitor student accomplishment of progress check. Use progress checklist to evaluate students.

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PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Environmental Support Specialist
BLOCK TITLE Water and Wastewater Analysis	

1. COURSE CONTENT — 2. TIME

3. Principles of Chemistry 20

a. Given a list of twenty chemical terms, elements, radicals and other related terms, match them with their definitions and/or symbols. Sixteen of the twenty terms must be correct. STS: 8b(1) MEAS: PC (2)

(1) Chemical terminology Day 13 (7)

(2) Solutions

* PHYSICAL CONDITIONING (1)

Day 14

b. Given a list of 15 chemical compounds and their formulas, match the chemical compounds with their formulas and indicate whether the compound is an acid, base, or salt. At least 12 of the 15 must be correct. STS: 8b(1) MEAS: PC (2)

(1) Acids (inorganic)

(2) Bases

(3) Salts

(4)

c. Given a list of ten compounds, write formulas describing each compound. Seven of the ten formulas must be correct. STS: 8b(1) MEAS: PC

(1) Steps required in writing balanced formulas for compounds

(2) Use of subscripts

(3) Enclosing radicals in parenthesis

(2)

d. Given five sets of reactants, write balanced chemical equations. Three of the five must be correct. STS: 8b(1) MEAS: PC

(1) Define chemical reactions

(2) Common types of chemical reactions

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3d. Continued from Day 14 Day 15

(3) Steps involved in writing balanced chemical equations (3)

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-II-3, Principles of Chemistry

Audio Visual Aids
Periodic Chart

Training Methods
Lecture/Discussion (10 hrs)
Performance (10 hrs)

Instructional Guidance
Discuss the basic principles of chemistry. Explain the importance of chemistry in the 566X1 career field. Write examples of chemical symbols, formulas and equations on the chalkboard to enhance learning objectives. Assign and monitor PC accomplishment. Use the Periodic Chart in the discussion of elements. Use progress checklist to evaluate students. Release students for physical conditioning.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Water and Wastewater Analysis

1. COURSE CONTENT	2. TIME
4. Laboratory Safety	2 Day 15
a. Given information pertaining to laboratory chemicals, identify the statements pertaining to their use and care as true or false. Three of the five answers must be correct. STS: 9a MEAS: PC	(1)
(1) Laboratory chemicals (2) Purpose and care of each chemical (3) Precautions when handling each chemical	
b. Given a list of 10 statements pertaining to the use and care of laboratory equipment, match the identifying statements to the correct piece of equipment. Seven of the ten answers must be correct. STS: 6b, 9b MEAS: PC	(1)
(1) List of laboratory equipment (2) Specialized laboratory equipment (3) Laboratory safety equipment (4) Percautions when using laboratory equipment	

SUPPORT MATERIAL AND GUIDANCE

Student Instruction Material
SW J3ABR56631 000-II-4, Laboratory Safety

Audio Visual Aids
Training Film: LFS 56-1, Laboratory Safety
Slide: Prenarrated Slide Set, NSS 56-3, Intro to Basic Equipment in Chemistry Laboratory

Training Methods
Lecture/Discussion (1 hr)
Performance (1 hr)

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Instructional Guidance

Discuss the proper use and care of laboratory chemicals and equipment. Show training film and slides on laboratory safety. Group students into teams and assign lab work stations. Show students where the lab equipment is located and explain procedures and use of the various equipment. Take inventory of chemicals and equipment to be used. Use inventory checklist for each lab station. Assign, monitor, and assist the students in the completion of the study guide/workbook exercise. Assign progress checks. Use progress checklist to evaluate students accomplishment of the progress checks.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Environmental Support Specialist

BLOCK TITLE
Water and Wastewater Analysis

1. COURSE CONTENT	2. TIME
5. Collect Water and Wastewater Samples	4 Day 15
a. Given information, the appropriate sampling device and a maximum of one instructor assist, collect and label a water sample to test for various impurities. STS: 9c(1) MEAS: PC	(2)
(1) Purpose of samples	
(2) Samples taken from the ground (well water)	
(3) Samples taken from the surface (lakes, rivers, streams, etc.)	
(4) Samples for dissolved gas	
(5) Samples for bacteriological analysis	
(6) Safety and personal hygiene	
* Physical Conditioning	(1) Day 16
b. Using given information, and a maximum of one instructor assist, list the procedures required for collecting a sample of wastewater and sample of sludge. STS: 9c(2), 9c(3) MEAS: PC	(2)
(1) Types of Samples	
(2) Procedures for collecting wastewater samples	
(3) Problems related to collecting wastewater samples	
(4) Sludge samples	
(5) Sampling devices	
(6) Procedures for collecting sludge samples	
(7) Safety and personal hygiene	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-II-5, Collect Water and Wastewater Samples

Training Methods
Lecture/Discussion (3 hrs)
Performance (1 hr)

Multiple Instructor Requirements
Equipment and Facilities - 2

Instructional Guidance
Emphasize the importance of proper sampling procedures when taking samples from various sampling points and sources. Explain that the water samples will be collected throughout the building during the water analysis criterion objective. The wastewater samples will be collected from the refrigerator in Block II for test purposes and classroom practicality. Explain that the performance of collecting wastewater samples will be accomplished in Block IV during the field trip. Stress personal hygiene and safety. Assign progress checks. Use progress checklist to evaluate students. Release students for physical conditioning.

* DENOTES MT

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Water and Wastewater Analysis

1. COURSE CONTENT	2. TIME
6. Water Analysis	18
a. Using appropriate laboratory equipment and testing procedures, test various samples of water for pH, temperature, and specific conductance. No more than one instructor assist is allowed for each test. STS: 9d(1), 9d(2), 9d(11) MEAS: PC	(4.5)
(1) Purpose of water analysis	
(2) Expression of test results	
(3) Commonly used methods of testing water	
(4) Temperature	
(5) Characteristics of pH	
(6) pH scale	
(7) Use of a pH meter	
(8) Specific conductance (solu-bridge)	
b. Using appropriate laboratory equipment and testing procedures, test various water samples for chlorine residual, turbidity, iron, and fluoride. No more than one instructor assist is allowed for each test. STS: 9d(3), 9d(14), 9d(17), 9d(25) MEAS: PC	(1.5)
(1) Colorimetric method	
(2) Chlorine residual	
6b. Continued from Day 16	Day 17 (5)
(3) Turbidity	
(4) Iron	
(5) Fluorides	

SUPERVISOR APPROVAL OF LESSON PLAN

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c. Given laboratory equipment, HACH DR3000 spectrophotometer methods manual, and a water sample, test the sample for true color, with no more than one instructor assist. STS: 9d(24) Meas: PC (1)

(1) Types of color

(2) Causes of color

(3) Testing for color

NOTE: CO 7e must be moved forward and started at this time due to the nature of the test to be performed.

7e. Given information, laboratory equipment, and a wastewater sample, perform a Biochemical Oxygen Demand Test. No more than two instructor assists are allowed. STS: 9d(7), 9d(8) MEAS: PC (2)

(1) Volumetric method

(2) Dissolved Oxygen Procedures (DO)

(3) Biochemical Oxygen Demand Procedures (BOD)

d. Given information. laboratory equipment, and various water samples, test the samples for hardness, acidity, and alkalinity. No more than two instructor assists are allowed for each test. STS: 7d(4), 9d(5), 9d(6) MEAS: PC Day 18 (3)

(1) Hardness

(2) Acidity

(3) Alkalinity

e. Given the types of phosphate compounds and a list of statements pertaining to phosphates, match each type of compound to the statements. Three out of five statements must be correct. STS: 9d(15) MEAS: PC (1)

(1) Types of phosphates

(2) Uses of phosphates

(3) Testing phosphates

f. Given five incomplete statements concerning chloride compounds, complete the statements as they pertain to the compound type, source and testing procedures. Three of the five completed statements must be correct. STS: 9d(13) MEAS: PC

(1) Types of chloride compounds

(2) Sources of chloride compounds

(3) Testing for chlorides

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material

SW J3ABR56631 000-II-6, Water Analysis

HO J3ABR56631 000-II-6, Laboratory Manual
HACH DR3000 Spectrophotometer Manual

Training Equipment

Electric pH Meter
Solu-bridge
Color Comparator
Nephelometric Turbidimeter
Spectrophotometer

Training Methods

Lecture/Discussion	(6 hrs)
Demonstration	(2 hrs)
Performance	(10 hrs)

Multiple Instructor Requirement

Equipment and Facilities - 2

Instructional Guidance

Discuss the methods of testing water samples and how to report the results. Explain each test to be performed and assist students in the performance of the water tests. Assign and monitor student completion of workbook exercises. Assign students to their lab stations, give them to their lab manual handout and emphasize personal safety throughout all training exercises. Assist students on the hardest parts of the tests. Assign progress checks. Use progress checklist to evaluate students.

MIR: Two qualified Block II instructors are required while students are performing tests in the laboratory. The students will require close supervision while handling acids, caustics, and delicate laboratory equipment. Two qualififed Block II instructors will also insure maximum participation in accomplishing criterion objectives.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Water and Wastewater Analysis

1. COURSE CONTENT	2. TIME
7. Wastewater Analysis	16 Day 18
a. Given information, laboratory equipment, and a wastewater sample, test the sample for Settleable Solids. No more than two instructor assists are allowed. STS: 9d(9) MEAS: PC	(2)
(1) Define settleable solids	
(2) Settleable solids test procedures	
(3) Expression of test results	
* PHYSICAL CONDITIONING	(1) Day 19
b. Given information, laboratory equipment, and a sludge sample, perform Total Solids and Volatile Solids tests. No more than two instructor assists are allowed for each test. STS: 9d(10), 9d(19) MEAS: PC	(6)
(1) Gravimetric method	
(2) Total solids test procedures	
(3) Fixed solids procedures	
(4) Volatile solids procedures	
c. Given information, laboratory equipment, and a wastewater sample, test the sample for Suspended Solids. No more than two instructor assists are allowed. STS: 9d(18) MEAS: PC	(2)
(1) Suspended Solids Test Procedures	
(2) Dissolved Solids Calculations	Day 20
d. Given information about coliform testing, complete four statements concerning the tests for Coliform Bacteria. Three of the four statements must be correct. STS: 9d(20), 9d(21) MEAS: PC	(2)
(1) Total coliform	

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(2) Fecal coliform

(3) Equipment used to test coliform

e. Given information, laboratory equipment, and a wastewater sample, perform a Biochemical Oxygen Demand test. No more than two instructor assists are allowed. STS: 9d(7), 9a, 9b, 9d(8) MEAS: PC (2)

(1) Volumeteric Method - Performed on Day 17

(2) D.O Procedures - Performed on Day 17

(3) B.O.D. Procedures - Performed on Day 17

(4) Review of initial DO/BOD setup

(5) B.O.D. Procedures - complete

(6) Calculations of test results

f. Given information related to wastewater analysis and five facts concerning the purpose of Chemical Oxygen Demand (COD) testing method, match the facts with the information. Three of the five must be correct. STS: 9d(23) MEAS: PC (1)

(1) Principle of the COD test

(2) Test Procedures

(3) Advantages/Disadvantages of the COD Test

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-II-7, Wastewater Analysis
HO 3ABR56631 000-II-6, Laboratory Manual

Audio Visual Aids
LFS 56-2, Gravimetric Analysis

Testing Equipment
Drying Oven
Muffle Furnace
Analytical Balance
Imhoff Cone
Imhoff Cone Stand

Training Methods

Lecture/Discussion	(7 hrs)
Demonstration	(1 hr)
Performance	(8 hrs)

Multiple Instructor Requirement

Equipment and Facilities - 2

Instructional Guidance

Discuss and explain the types of tests performed on wastewater samples. Explain to the students that they will perform a total, fixed, volatile and suspended solids test. Explain the relationship that one test has on the other. Make sure that the students realize that the fixed solids test is a part of the volatile solids test. Observe the students while they use their precision equipment. Assign, monitor and assist the students in the SW performances. Objective 7e, BOD/DO test must initially be prepared and set up to allow approximately a three to five day incubation period. Completion of this test will be performed on training day 20, Block II. Objective 7b (2)(3)(4) accomplishes three tests in sequence; these tests are all performed on the same sludge sample and naturally follow a given order. Suspended solids will be run with wastewater samples, raw, primary and final. Dissolved solids are derived mathematically from the results of 7c(1) and 7b(2). Emphasize safety when handling hot samples. Assist the students on the hardest parts of the tasks. Assign progress checks. Use performance checklist to evaluate students accomplishment of the progress checks. Release students for physical conditioning.

MIR: Two qualified Block II instructors are required while students are performing tests in the laboratory. The students will require close supervision while handling acids, caustics, hot samples, and delicate equipment. Two instructors will also insure maximum participation in the accomplishment of criterion objectives.

8. Written Test and Test Critique (2)

    * Physical Conditioning (1)

    * Denotes MT

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Water Supplies and Treatment

1. COURSE CONTENT	2. TIME
1. Water Well Operation and Maintenance	8 Day 21
a. Given incomplete statements about ground water and water wells, complete each statement by making written responses. Four of the six responses must be correct. STS: 10a MEAS: PC	(5)
(1) Origin of ground water	
(2) Exploration for ground water	
(3) Well construction	
(4) Well problems and maintenance	
b. Using data pertaining to wells, define terms and calculate static, pumping, and drawdown levels with a maximum of one instructor assist. STS: 10b MEAS: PC	(3)
(1) Definition of terms	
(2) Mathematical formula	

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-III-1, Water Well Operation and Maintenance
AFR-91-26 Maintenance and Operation of Water Supply, Treatment and Distribution Systems

Training Equipment
Trainer, Water Well

Training Methods
Lecture/Discussion (5 hrs)
Performance (3 hrs)

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Instructional Guidance

Emphasize the importance of well water as a major supply of water for military installations throughout the world. Discuss the components of wells, principles of water well operation and maintenance. Demonstrate calculation of static level, pumping level and drawdown. Operate water well trainer to demonstrate well operation. Have students complete progress check. Use progress checklist to evaluate students.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Water Supplies and Treatment

1. COURSE CONTENT	2. TIME
2. Water Treatment Processes	14 Day 22
a. Given information related to water clarification, match statements identifying the facts and terms which pertain to water clarification. Six of the nine must be correct. STS: 10c(1) MEAS: PC	(6)
(1) Clarification defined (2) Plain sedimentation (3) Coagulation - flocculation (4) Chemistry of coagulation - flocculation (5) Factors affecting the coagulation - flocculation process (6) Determine the correct chemical dosage for coagulation - flocculation (Jar Test) (7) Sedimentation (In Plant) (8) Filtration	
b. Using information about water softening, identify facts and terms by completing ten statements. Seven of the ten must be correct. STS: 10c(2) Meas: PC	(2)
(1) Softening defined (2) Kinds of hardness (3) Methods used to remove hardness from water	

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c. Given information related to removal of taste, odor and color, list the methods used to remove taste, odor, and color in water supplies. Five of the seven must be correct. Day 23 (2)
STS: 9d(26), 10c(6) MEAS: PC

(1) Causes of Taste and Odor

(2) Removal of taste and odor

(3) Causes of color

(4) Removal of color

d. Given information related to water treatment processes, match facts and terms related to stabilization, disinfection, fluoridation and defluoridation. Six of the ten must be correct. (4)
STS: 10c(3), 10c(5), 10c(7), 10c(8) MEAS: PC

(1) Stabilization

(2) Disinfection

(3) Fluoridation

(4) Defluoridation

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-III-2, Water Treatment Processes

Training Methods

Lecture/Discussion	(10 hrs)
Performance	(4 hrs)

Audio Visual Aids
47903, A Silent Toast to Water

Instructional Guidance
Introduce clarification by showing film: "A Silent Toast to Water". Discuss the processes of clarification; softening; taste, odor and color control; stabilization, disinfection, fluoridation, and defluoridation. Set up Jar Test and let it run during Lecture/Discussion period. After appropriate time for coagulation, complete Jar Test. Have students complete progress check. Use progress checklist to evaluate students.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Environmental Support Specialist
BLOCK TITLE Water Supplies and Treatment	

1. COURSE CONTENT	2. TIME
3. Monitor/Operate and Maintain Water Treatment Plant Equipment	14 Day 23
a. Given statements about chemical mixing tanks, identify as true or false the statements concerning the monitoring and operation of chemical mixing tanks. Three of the four must be correct. STS: 10d(2) MEAS: PC	(1)
(1) Rapid mix	
(2) Slow mix	
(3) Dilution/mixing tanks	
* Physical Conditioning	(1) Day 24
b. During a field trip to the local municipal water treatment plants, monitor the operation of plant components by making a written response IAW a checklist. No more than three instructor assists allowed. STS: 6b, 10d(3), 10d(4), 10d(7), 11a(1) 11a(2), 11a(3)(a), 11a(3)(b), 11a(3)(c), 11a(4), 11a(5) Meas: PC	(8)
(1) Safety	
(2) Plain sedimentation	
(3) Measuring devices	
(4) Chemical feeders (gas, solution, dry)	
(5) Horizontal sedimentation clarifier/softner	
(6) Filters	
(7) Control devices	
(8) Pumps and valves	
(9) Upflow clarifier	
(10) Review of field trip	

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c. Using information and the water plant trainer, work as a team to monitor/operate the trainer, with no more than three instructor assists. STS: 10d(3), 10d(7) MEAS: PC Day 25 (3.0)

(1) Plain sedimentation tank

(2) Chemical mixing tank

(3) Horizontal sedimentation clarifier/softener

(4) Filters

(5) Clear wells

(6) Water tower (1.0)

d. Using information and the water plant trainer and equipment, work as a team to perform the required maintenance on the trainer equipment. No more than two maintenance problems may be missed. STS: 10e(2), 10e(3), 10e(7) MEAS: PC

(1) Plain sedimentation tank

(2) Chemical mixing tanks

(3) Horizontal sedimentation clarifier/softener

(4) Filters

(5) Clear wells

(6) Water tower (.5)

e. Using AFR 91-26, complete statements concerning the purpose and types of aerators. Five of the seven must be correct. STS: 10d(1) MEAS: PC

(1) Purpose of aeration

(2) Types of aeration (.5)

f. Using AFR 91-26, match the maintenance procedures used for each type of aerator. Three of the five must be correct. STS: 10e(1) MEAS: PC

(1) Types of aerators

(2) Maintenance of aeration units

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material

SW J3ABR56631 000-III-3, Monitor/Operate and Maintain Water Treatment Plant Equipment
AFR 91-26, Maintenance and Operation of Water Supply, Treatment and Distribution Systems

Audio Visual Aids

LFS 56-7, Water Treatment Plant Operation

Training Equipment

Trainer, Water Treatment Plant System

Training Method

Lecture/Discussion (5.0 hrs)
Performance (8.0 hrs)

Instructional Guidance

Stress safety on field trip and while operating water trainer. Stress safety in handling chemicals and when working around electrical equipment and moving parts. Show training film LFS 56-7, Water Treatment Plant Operation at specified criterion objectives. Have students complete workbook exercise during field trip. Operate the water plant trainer with hands on training for the students, monitoring the students closely for safety purposes. Place five malfunctions in water trainer for progress check. Have students work in pairs to correct them. Clean equipment and room prior to dismissal of students. Use progress checklist to evaluate students.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Environmental Support Specialist
BLOCK TITLE Water Supplies and Treatment	

1. COURSE CONTENT	2. TIME
4. Monitor/Operate and Maintain Ion Exchange (Demineralization) Units	17 Day 25
a. Given terms and statements pertaining to an ion exchange unit, match the terms to the statements. Twelve of the seventeen must be correct. STS: 10c(4) MEAS: PC	(2)
(1) Purpose	
(2) Theory of ion exchange	
(3) Characteristics of ion exchange resins	
* Physical Conditioning	(1)
4a. Continued from Day 25	Day 26 (3)
(4) Types of ion exchangers	
(5) Components of demineralizers	
(6) Cycles of operation	
b. Given information, ion exchange softener and demineralization units, work as a team to monitor/operate the ion exchange units, with no more than four instructor assists. STS: 10d(8), 10d(9), 10d(10) MEAS: PC	(5)
(1) Water softener	
(2) Dual bed demineralizer	
4b. Continued from Day 26	Day 27 (4)
(3) Mixed bed demineralizer	
c. Given information and a ion exchange trainer, work as a team to maintain the unit, with no more than one instructor assist. STS: 10e(8), 10e(9), 10e(10) MEAS: PC	(3)

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(1) Water softener

(2) Dual bed demineralizer

(3) Mixed bed demineralizer

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-III-4, Monitor/Operate and Maintain Water Treatment Plant Equipment

Training Equipment
Trainer, Water Plant

Training Methods

Lecture/Discussion	(6.0)
Performance	(9.0)
Demonstration	(2.0)

Instructional Guidance
Explain what an ion exchange (demineralizer) unit is used for and how it works. Discuss the operating procedures and point out the various components, explain their purpose. Have students operate the unit according to your guidance and operating instructions. Place three malfunctions in the unit for students to correct. Use care and stress safety throughout performance of the unit. Assign and monitor student accomplishment of progress check. Use progress checklist to evaluate students. Annotate ATC Forms 98 and 667.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR

COURSE TITLE
Environmental Support Specialist

BLOCK TITLE
Water Supplies and Treatment

1. COURSE CONTENT	2. TIME
5. Monitor/Operate and Maintain Electrodialysis Demineralizer Unit	4 Day 27
a. Given information and an electrodialysis demineralization unit, work as a team to monitor/operate the unit, with no more than three instructor assists. STS: 10d(5) MEAS: PC	(1)
(1) Application	
(2) Principle of operation	
5a. Continued from Day 27	Day 28
(3) Components of unit	(1)
(4) Operating procedure	
b. Given information and a electrodialysis demineralizer, work as a team to maintain the unit, with no more than two instructor assists. STS: 10e(5) MEAS: PC	(2)
(1) Test for salinity (TDS)	
(2) Electro-membrane stack probing	
(3) Electro-membrane stack disassembly/reassembly	

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-III-5, Monitor/Operate and Maintain Electrodialysis Demineralizer Unit

Training Equipment
Trainer, Electrodialysis Demineralizer Unit

Training Method

Lecture/Discussion	(2.0)
Performance	(1.5)
Demonstrate	(0.5)

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SUPPORT MATERIALS AND GUIDANCE (CONT'D)

Instructional Guidance

Explain what an electrodialysis unit is used for and how it works. Discuss the operating procedures and point out the various components, explaining their purpose. Have the students operate and maintain the unit according to your guidance and trainer checklist. Use care with equipment and stress safety throughout performance of unit. Assign and monitor student accomplishments of progress checks. Use progress checklist to evaluate students.

Instructor Reference Material

Aquamite I, Operating and Maintaining Manual

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Environmental Support Specialist
BLOCK TITLE Water Supplies and Treatment	

1. COURSE CONTENT	2. TIME
6. Field Water Purification Units	12 Day 28

a. Given a sketch of a proposed water point and site selection criteria, locate and identify the correct site to set up the unit according to TM 5-700. Three of the four must be correct. STS: 8e, 14a, 14b, 14c, 15e(1)a MEAS: PC (2.0)

(1) Determine amount of water needed

(2) Select raw water source

(3) Perform stream survey

(4) Lyster bag

b. Given a diagram and information related to the ERDLATOR, locate and identify components. Ten of the twelve statements must be correct. STS: 14d(1), 14d(2), 14e MEAS: PC (2.0)

(1) Purpose of F.W.P.U.

(2) Types of field units

(3) Principles of operation

(4) Components of ERDLATOR (600 gph)

* Physical Conditioning (1)

Day 29

c. Using TO 40W4-9-1, and information related to the operation of the ERDLATOR, match statements pertaining to the operation of the unit. Twelve of the fifteen must be correct. STS: 14e Meas: PC (1.0)

(1) Operational procedures of unit

(2) Operational procedures of filter

(3) Shutdown and safety procedures (2.0)

d. Using TO 40W4-9-1, complete statements pertaining to preventive maintenance procedures and troubleshooting operational problems of a 600 gph ERDLATOR. Nine of the fifteen statements must be correct. STS: 10e(4) MEAS: PC

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(1) Preventive maintenance services

(2) General troubleshooting

e. Given a diagram and information related to the Reverse Osmosis Water Purification Unit (ROWPU), locate and identify the ROWPU components IAW TO 40W4-13-1. Seven of the eleven matched components must be correct. STS: 10d(6), 14d(2) MEAS: PC (3)

(1) Principle of reverse osmosis

(2) Types of reverse osmosis components

(3) Application of reverse osmosis units

(4) Advantages/Disadvantages of reverse osmosis units

f. Using TO 40W4-13-2 and related information, write the correct procedures used to perform maintenance on the Reverse Osmosis Water Purification Unit. Six of the ten procedures must be correct. STS: 10e(6) MEAS: PC (2)

(1) Operator preventive maintenance (ROWPU)

(2) Maintenance procedures (ROWPU)

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-VI-1-6, Field Water Purification Units
TO 40W4-9-1, Field Water Purification Unit 600 gph
TO 40W4-13-2, Operator's Maintenance Manual
TM 5-700, Field Water Supply

Audio Visual Aids
Training Films: LFS 56-3A, Site Selection and Set Up of the 600 gph Field Water Purification Unit
LFS 56-4, Operation of the 600 gph Field Water Purification Unit
MN 11001A, Safe Water-Field Sanitation and Hygiene

Slides: Slides on Reverse Osmosis Water Purification Unit

Training Equipment
Field Water Purification Unit 600 gph (ERDLATOR)

Training Methods
Lecture/Discussion (6 hrs)
Performance (6 hrs)

Instructional Guidance
Explain and discuss the purpose and importance of the field water purification units and their role in the Air Force and with contingency operations. Discuss the importance of securing a safe site location and water source. Explain the operation and maintenance requirements of these units using both technical publications. Show training films LFS 56-3A, LFS 56-4, and MN 11001. Show slide of ROWPU and explain the presentation. Assign and monitor student accomplishment of progress check. Use progress checklist to evaluate students. CO #6e and 6f will be completed during the field trip on training day 30.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Water Supplies and Treatment

1. COURSE CONTENT	2. TIME
7. Swimming Pools	5 Day 30
a. Using information from AFR 91-26 relating to the operational principles of swimming pools, match the facts and terms to the identifying statements. Eight of the twelve matched statements must be correct. STS: 13a MEAS: PC	(2)
(1) Principles of operation (2) AF Form 708 (3) Safety	
b. Identify the construction features and major components of the pool by making written responses to complete a diagram. Eight of the twelve responses must be correct. STS: 13b, 13c MEAS: PC	(1)
(1) Construction features (2) Major components	
c. Given information, list the maintenance requirements of the pool. No more than one instructor assist is allowed. STS: 11b(3)(a), 13d MEAS: PC	(1)
(1) Hair catcher (2) Filter servicing (3) Pumping equipment (4) Chemical feeder (chlorine cylinder) (5) Safety equipment	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-III-7, Swimming Pools
AFR 91-26, Maintenance and Operation of Water Supply, Treatment and
Distribution Systems

Audio Visual Aids
Film 51884, Clean Clear Water

Training Equipment

Training Methods

Lecture/Discussion	(1.5 hrs)
Performance	(3.5 hrs)

Instructional Guidance
Discuss the operation and maintenance of swimming pools and associated equipment. Observe and stress safety precautions associated with activites around the pool. Assign students progress checks. Use progress checklist to evaluate students. Show Training film, 51889, Clean, Clear Water.

8. Written Test and Test Critique (2)

* PHYSICAL CONDITIONING (1)

* DENOTES MT

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Wastewater Treatment and Disposal

1. COURSE CONTENT	2. TIME
1. Characteristics of Wastewater	4 Day 31 (4)

a. Given information concerning the characteristics and composition of wastewater and a list of incomplete statements and phrases, write the terms or phrases to complete each statement. Fifteen of the twenty statements must be correct. STS: 8d Meas: PC

(1) Characteristics

(2) Sources

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-IV-1, Characteristics of Wastewater
AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

Audio Visual Aids
Training Film: 46842, The Valley

Training Methods
Lecture/Discussion (2.5 hrs)
Performance (1.5 hrs)

Instructional Guidance
Discuss the importance of knowing the characteristic of wastewater, and the problems which may occur if not treated correctly. Show the film, The Valley. Assign and monitor student accomplishment of progress checks. Use progress checklist to evaluate students.

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PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Wastewater Treatment and Disposal

1. COURSE CONTENT	2. TIME
2. Wastewater Plant Safety	2 Day 31 (2)

a. Given a list of unsafe conditions and violations, select the safe rule or practice to eliminate the safety violation. Seven of the ten must be correct. STS: 6a Meas: PC

(1) Safety regulation

(2) Safety program

(3) Protective equipment

(4) Safety rules and practices

(5) Hazardous operation

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-IV-2, Wastewater Plant Safety

Training Methods
Lecture/Discussion (1.5 hrs)
Performance (.5 hrs)

Instructional Guidance
Discuss the importance of having a good shop safety program at the wastewater treatment plant, and what protective equipment is available. Later talk about the safety rules and practices. Complete the lesson by talking about the types of dangers encountered around a wastewater treatment plant. Stress personal involvement and the buddy system when working in the wastewater treatment plant. Assign progress check. Record results on ATC Form 98 and 667.

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PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Wastewater Treatment and Disposal

1. COURSE CONTENT	2. TIME
3. Pollution Control Policies and Program	4

3. Pollution Control Policies and Program — 4

a. Given information concerning Environmental Pollution Control Policies and Programs and a list of incomplete statements, write the phrase or term to complete each statement. Seven of ten must be correct. STS: 8d Meas: PC — Day 31 (2)

(1) Why controls are necessary

(2) Federal and state regulations

(3) Military regulations

(4) Wastewater pollution control

(5) Maintain and submit forms as required by directives

b. Given information related to hazardous waste material, select the phrase or term which correctly answers the written statements. Seven of the ten answers must be correct. STS: 8e Meas: PC — Day 32 (2)

(1) Types of hazardous wastes

(2) Sources of hazardous waste

(3) Disposal methods

(4) Containment and storage

(5) Safety in handling/treating hazardous waste

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-IV-3, Pollution Control Policies and Program
AFP 19-5, Environmental Quality Control Handbook
AFM 91-32, Operation and Maintenance of Domestic and Industrial
Wastewater Systems

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Training Methods
Lecture/Discussion (3 hrs)
Performance (1 hr)

Instructional Guidance
Discuss the importance of environmental Pollution Control Policies and Programs. Discuss the problems in the treatment and handling of hazardous waste. Assign and monitor student accomplishment of progress check. Use progress checklist to evaluate students.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Wastewater Treatment and Disposal

1. COURSE CONTENT	2. TIME
4. Operation and Maintenace of Septic Tanks	2 Day 32 (2)

a. Given a list of statements concerning the construction features, operational practices and maintenance of septic tanks, complete each statement. Ten of the fifteen must be correct.
STS: 12b(21), 12c(21) Meas: PC

(1) Construction features of septic tanks

(2) Operation of septic tanks

(3) Operation of leaching field

(4) Methods used to protect tile fields

(5) Maintenance procedures

(6) Records kept on septic tanks and leaching fields

(7) Dosing siphon

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-IV-4, Operation and Maintenance of Septic Tanks

Training Methods
Lecture/Discussion (1.5 hrs)
Performance (.5 hrs)

Instructional Guidance
Discuss a brief history of our wastewater treatment and disposal system up to the use of septic tanks and today's modern treatment and disposal methods. Explain the purpose, use and operation of a septic tank and leaching field connection. State the maintenance and care of septic tanks and items for record keeping. Assign and monitor student accomplishment of progress check. Use progress checklist to evaluate students.

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NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE

Wastewater Treatment and Disposal

1. COURSE CONTENT	2. TIME
5. Operation and Maintenance of Pretreatment Units	1 Day 32 (1.0)

a. Given information pertaining to pretreatment units and processes, match the terms and phrases to each type of processing unit. Ten of the fifteen must be correct. STS: 12a(1), 12b(20), 12c(20), 12d(1), 12d(3) Meas: PC

(1) Definition of pretreatment

(2) Purpose of Pretreatment

(3) Grease traps/oil separators

(4) Makeup of wastewater collection system

(5) Common troubles of collection system

(6) Screens and lift stations

SUPPORT MATERIAL AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-IV-5, Operation and Maintenance of Pretreatment Units
AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater System

Training Methods
Lecture/Discussion (.5 hr)
Performance (.5 hr)

Instructional Guidance
Discuss the purpose and primary reason for using special treatment devices to separate the harmful wastewater contaminants before they reach the domestic treatment plant. Explain the makeup of wastewater collection systems to include lift stations, pumps, wells or screens. Assign and monitor student accomplishment of progress check. Use progress checklist to evaluate students.

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PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Environmental Support Specialist

BLOCK TITLE
Wastewater Treatment and Disposal

1. COURSE CONTENT	2. TIME

6. Operation and Maintenance of Preliminary Treatment Units 3.0 Day 32

a. Demonstrate a knowledge of the purpose of preliminary treatment units and subsystems by making written responses to questions that pertain to preliminary wastewater treatment. Seven of the ten responses must be correct. STS: 12a(2), 12b(2), 12b(3), 12b(4) Meas: PC (1.5)

(1) Definition of preliminary treatment

(2) Screens

(3) Grit removers

(4) Shredders

(5) Preaeration

b. Using information, list the required maintenance for screens, grit removers, shredders, preaerators and measuring devices according to AFM 91-32. Six of ten must be correct. STS: 11b(4), 12c(2), 12c(3) 12c(4) Meas: PC (.5)

(1) Screens

(2) Grit removers

(3) Shredders

(4) Preaeration

(5) Measuring devices

c. Using AFM 91-32, solve three operational problems concerning the preaeration unit on the preliminary treatment process. STS: 12b(4) Meas: PC (.5)

(1) Purpose of preaeration

(2) Monitoring

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d. While on a field trip to a local municipal wastewater treatment plant, monitor the operation of the grit remover, screens and shedders. Use a checklist to evaluate the operating procedures against the standards set forth in AFM 91-32. Students checklist must correspond to 60% of entries made by instructors' evaluation of each item. STS: 12b(2), 12b(3) Meas: PC (.5)

1. Grit remover

2. Screens/shredders

SUPPORT MATERIAL AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-IV-6, Operation and Maintenance of Preliminary Treatment and Units
AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

Audio Visual Aids
Slide Set - Preliminary Treatment

Training Equipment
Trainer, Wastewater Plant

Training Methods
Lecture/Discussion (2 hrs)
Performance (1 hr)

Instructional Guidance
Discuss the operation and maintenance of preliminary treatment units and their components. Explain the purpose and location of each within the wastewater plant. Show the preliminary units on the trainer to the students. Show and narrate a slide presentation of this equipment. Assign and monitor student accomplishment of progress check. Objective 3d will be accomplished on Day 33 on the field trip. Use progress checklist to evaluate students.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Wastewater Treatment and Disposal

1. COURSE CONTENT	2. TIME
7. Operation and Maintenance of Primary Treatment Units	15 Day 33
a. While visiting a municipal wastewater plant, observe the operation of the plant and equipment. Use a schematic to trace the flow through the system and a checklist to list the maintenance and safety items with no more than three instructor assists. STS: 6a, 6b, 11a(1), 11a(2), 11a(3)(a), 11a(4), 11a(5), 11a(8), 11a(9), 12a(1), 12a(2), 12a(3), 12a(7), 12b(5), 12b(16), 12b(17), 12c(2), 12c(3), 12c(4), 12c(5), 12c(16), 12c(17), 12d(1), 12d(2) Meas: PC	(6)
(1) Overview of field trip	
(2) Plant safety and personal hygiene	
(3) Pretreatment (lift station)	
(4) Preliminary units	
(5) Primary units	
b. Using given information and a sampling device, and working as a team, collect a wastewater and a sludge sample from various sampling points within the plant, with no more than two instructor assists. STS: 9c(2), 9c(3) Meas: PC	(1)
(1) Types of samples (grab/composite)	
(2) Methods of collection	
(3) Sampling points	
*Physical Conditioning	(1)

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c. Following written instructions, identify the operation of primary wastewater units by making written responses to questions according to AFM 91-32. Seven of the ten answers must be correct. STS: 9d(27), 12a(3), 12a(7), 12b(5), 12b(16), 12b(17), 12b(18), 12b(19) Meas: PC (5)

(1) Definition of primary treatment

(2) Primary settling tanks

(3) Imhoff tank

(4) Separate digester and components

(5) Sludge drying

(6) Sludge disposal

d. Following written instructions, list the maintenance practices of primary wastewater units by making written responses to questions according to AFM 91-32. Eight of the twelve responses must be correct. STS: 12a(3), 12c(5), 12c(16), 12c(17), 12c(18), 12c(19) Meas: PC (2)

(1) Primary settling tanks

(2) Imhoff tanks

(3) Separate digester and components

(4) Sludge drying

(5) Sludge disposal

e. Given five statements concerning the grease and volatile acids test, indicate if the statements are true or false. Three of the five statements must be correct. STS: 9d(12), 9d(16) Meas: PC (1)

(1) Test for grease

(2) Test for volatile acids

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

SW J3ABR56631 000-IV-7, Operation and Maintenance of Primary Treatment Units

AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

Audio Visual Aids

Slides - Primary Wastewater Treatment

Film - FLC 13/94, Municipal Sewage Treatment Process

Film - LFS - 56-6, Everything You Wanted to Know About Wastewater

Training Equipment

Trainer: Wastewater Treatment Plant System

Training Methods

Lecture/Discussion (8 hrs)

Performance (7 hrs)

Instructional Guidance

Discuss the operation and maintenance of primary wastewater treatment units and components. Explain the difference between primary treatment and the previous systems. Show the wastewater trainer when explaining and describing the operation and construction features of these units. Give a slide presentation to the students concerning primary treatment units and components. Visit the Wichita Falls wastewater plant and explain and identify the wastewater systems available. Observe all safety precautions and practice shop and plant safety during the entire field trip. If inclement weather or unavailable transportation prevents taking the field trip, these days will be alternated with another lesson. After discussion of wastewater samples, take students to the base wastewater plant to collect wastewater samples, completing their criterion performance objective. Assign and monitor student accomplishment of progress checks. Use progress checklist to evaluate students. Insure that Progress Check 6d and 7a are accomplished on the field trip, annotate ATC Form 98 and 667.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Wastewater Treatment and Disposal

1. COURSE CONTENT	2. TIME
8. Operation and Maintenance of Secondary Treatment Units	27 Day 35
a. Given a list of incomplete statements and a list of terms and phrases relative to the operation of trickling filters, complete the statements IAW AFM 91-32. Eight of the twelve completed statements must be correct. STS: 12a(4), 12b(6), 12c(6) Meas: PC	(4)
(1) Definition of secondary treatment	
(2) Basic features of trickling filters	
(3) Principles of filter operation	
(4) Factors affecting filter operation	
(5) Types of Filters	
(6) Operational problems/corrective actions	
(7) Final settling tanks	
b. Given information and a troubleshooting guide, identify the maintenance requirements for trickling filters by following a troubleshooting guide with a maximum of one instructor assists. STS: 12b(6), 12c(6) Meas: PC	(1)
(1) Maintenance checklist	
(2) Troubleshooting table	
c. Given information and incomplete statements related to wastewater lagoons, write the correct term or phrase to each statement according to AFM 91-32. Six of the ten responses must be correct. STS: 12b(12), 12c(12) Meas: PC	(2)
(1) Types of lagoons	
(2) Site and construction features	
(3) Lagoon processes and operation	

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(4) Maintenance of oxidation ponds

(5) Laboratory testing

(6) Odor control

*Physical Conditioning (1)

Day 36

d. Define the activated sludge process and principles, by matching the correct phrase or term to a statement related to activated sludge. Seven of the eleven responses must be correct. STS: 12a(4), 12b(9), 12b(10), 12b(11) Meas: PC (2)

(1) Define activated sludge

(2) Description of the process/principles

(3) Description of the equipment

e. Indicate the basic facts about activated sludge systems by matching the proper facts to a list of various types of systems. Twelve of the seventeen must be correct. STS: 12a(4), 12b(9), 12b(10), 12b(11) Meas: PC (3)

(1) Conventional activated sludge units

(2) Contact stabilization activated sludge units

(3) Extended aeration activated sludge units (oxidation ditches)

f. Indicate the corrective action to take, when operational problems develop, by listing the proper corrective action for each problem according to AFM 91-32. Two of four must be correct. STS: 12a(4). Meas: PC (1)

(1) Aeration tanks

(2) Secondary clarifier (final)

(3) Organic/Hydraulic loading

g. Match a list of incomplete statements concerning submerged contact aeration units with the correct term to complete them. Three of the five statements must be correct. STS: 12b(7) Meas: PC (1)

(1) Construction features

(2) Principles of operation

(3) Factors which affect efficiency

h. Given five statements concerning a rotating fixed media biological unit, indicate if the statements are true or false. Three of the five statements must be correct. STS: 12b(8), 12c(8) Meas: PC (1)

(1) Construction features

(2) Principles of operation

(3) Maintenance

Day 37

i. Given a list of statements concerning wastewater plant safety, correct the statements which are false. Seven of ten must be correct. STS: 6b Meas: PC (1)

(1) Plant safety

(2) Personal hygiene

j. While visiting a municipal wastewater plant, observe the operation of the plant and equipment. Use a schematic to trace the flow and identify the components. Use a checklist to list the maintenance and safety items. With no more than three instructor assists. (5)

STS: 11a(1), 11a(2), 11a(3)(a), 11a(4), 11a(5), 11a(8), 11a(9), 12a(1), 12a(2), 12a(3), 12a(4), 12a(6), 12a(7), 12b(2), 12b(3), 12b(5), 12b(6), 12b(10), 12b(11), 12b(12), 12b(16), 12b(17), 12c(2), 12c(3), 12c(4), 12c(10), 12c(11), 12c(12), 12c(16), 12c(17) Meas: PC

(1) Secondary treatment (Slide Presentation)

(2) Overview of Field Trip

(3) Plant safety and personal hygiene

(4) Extended aeration (Burkburnett)

(5) Oxidation ponds (Electra)

(6) Contact stabilization (Iowa Park)

*End-of-Course Appointments (2)

Day 38

k. Given information related to laboratory test controls of an activated sludge system, identify the type and reason for each test control according to AFM 91-32. Four of six must be correct. STS: 9d(22) Meas: PC (1)

(1) Dissolved oxygen (D.O.)

(2) Sludge age (SA)

(3) Mixed liquor suspended solids

(4) Settling Rate (SVI/SDI)

(5) Microscopic examination

l. Given information and a troubleshooting guide, identiy the maintenance requirements for each activated sludge system by selecting the correct action to take. Three of five must be correct. STS: 12c(7), 12c(9), 12c(10), 12c(11) Meas: PC (1.5)

(1) Operating and maintenance checklist

(2) Troubleshooting table

m. Working as a team and using a schematic to operate the wastewater plant trainer, locate the correct valves and pumps to control the flow of water through each processing unit with no more than one instructor assist. STS: 11a(1), 11a(2), 12a(1), 12a(2), 12a(3), 12a(4), 12a(7) Meas: PC (1.0)

(1) Preview of trainer operation

(2) Flow through primary treatment unit

(3) Flow through pretreatment units

(4) Flow through secondary treatment

(5) Draw sludge to drying beds

n. Using the operating wastewater plant trainer and performing in groups of two, direct the flow of wastewater through all the wastewater processing units with no more than three instructor assists. STS: 12b(2), 12b(3), 12b(4), 12b(5), 12b(6), 12b(16), 12b(17) Meas: PC (2.5)

(1) Drain and clean trainer

(2) Grit remover

(3) Screens/shredders

(4) Primary settling tanks

(5) Digesters

(6) Imhoff tank

(7) Drying beds

(8) Trickling filter

(9) Shut down system and clean

*End-of-Course Appointments (2)

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR56631 000-IV-9, Operation and Maintenance of Secondary Treatment Units
AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Plants

Audio Visual Aids
Slide Set (Blk IV)
Film - LFC 13/94, Municipal Sewage Treatment Process

Training Equipment
Trainer: Wastewater Plant

Training Methods
Lecture/Discussion (13 hrs)
Performance (14 hrs)

Instructional Guidance
Discuss the operation and maintenance of secondary wastewater treatment, unit and components. Explain the difference between secondary treatment and previous systems. Show the wastewater plant trainer when explaining and describing the operation and construction features of these units. Give a slide presentation to the students concerning secondary treatment units and components. Visit local municipal wastewater plants and explain and identify the wastewater system available. Observe all safety precautions and practice shop and plant safety during the entire field trip. If inclement weather or unavailability of transportaion prevents taking the field trip, these days will be alternated with another lesson. Operate the wastewater trainer.

Guide the students while using the progress check directions of operation. Flow water through the complete system following SOP in the progress check. During trainer operation, troubleshoot the system. Assign and monitor student accomplishment of progress checks. Use progress check to evaluate students.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Environmental Support Specialist

BLOCK TITLE
Wastewater Treatment and Disposal

1. COURSE CONTENT	2. TIME
9. Tertiary (Advanced) Treatment	4 Day 39

a. Given a list of incomplete statements and a list of terms and phrases related to advanced wastewater treatment, select the correct term or phrase that pertains to each statement. Seven of the ten selections must be correct. STS: 9d(27), 9d(28), 9d(30), 12a(5), 12b(13), 12b(14), 12b(15), 12c(13), 12c(14), 12c(15) Meas: PC (2)

(1) Define Tertiary (Advanced) Treatment (AWT)

(2) Methods of tertiary treatment

b. Given information and a troubleshooting guide and four problems, list one corrective operational or maintenance procedure for a phosphate tank, denitrification unit and a carbon filter IAW AFM 91-32. Two of the four procedures must be correct. STS: 12c(13), 12c(14), 12c(15) Meas: PC (2)

(1) Operation and maintenance problems

(2) Troubleshooting

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-IV-9, Tertiary (Advanced) Treatment
AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

Audio Visual Aids
Films: 46817 - A Town That Washes Its Water
46626 - The Living Filter

Training Methods
Lecture/Discussion (2.5)
Performance (1.5)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
J3ABR56631 000	IV	9	4 June 1984	83

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PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Environmental Support Specialist

BLOCK TITLE
Wastewater Treatment and Disposal

1. COURSE CONTENT — 2. TIME

10. Disinfection Process 2 Day 39

a. Given a schematic of a wastewater plant, identify the points where chlorine may be applied and complete written statements related to wastewater disinfection. Ten of the fifteen completed statements must be correct. STS: 12a(6) Meas: PC (2)

(1) Definition of disinfection process

(2) Applying chlorine

(3) Forms of chlorine

(4) Chlorine handling and storage

(5) Other disinfectants

*End-of-Course Appointments (2)

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-IV-10, Disinfection Process
AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

Training Methods
Lecture/Discussion (1.0)
Performance (1.0)

Instructional Guidance
Discuss the disinfection process throughout the wastewater system. Explain the chemistry of chlorine and how and where it is applied within the plant system. Emphasize the importance and safety of handling and storing the different forms of chlorine. Briefly discuss the other types of disinfectives and the maintenance of chlorine equipment. Use AFM 91-32 for information and guidance. Assign and monitor student accomplishment of progress check. Use progress checklist to evaluate students.

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
J3ABR56631 000	IV	10	12 May 86 (Chg)	85

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Environmental Support Specialist

BLOCK TITLE
Wastewater Treatment and Disposal

1. COURSE CONTENT	2. TIME

11. Logs and Reports — 2
Day 40
(2)

a. Given pertinent data about a wastewater plant and AF Forms 1462 and 1463, complete the forms. Four of the seven entries must be correct. STS: 5i, 8d Meas: PC

(1) Purpose of records

(2) Types of records

(3) Requirements of records

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Material
SW J3ABR56631 000-IV-11, Logs and Reports

Training Methods
Lecture/Discussion (1.0)
Performance (1.0)

Instructional Guidance
Discuss the various types of logs and reports an operator should document and keep on file. Explain the purpose and use of equipment and utility logs. Stress the importance of AF Forms 1462 and 1463. Assist students with information and documentation of these forms. Assign and monitor student accomplishment of progress check. Use progress checklist to evaluate students.

6. Written Test and Test Critique — 2

7. Course Critique and Graduation — 2

*Predeparture Safety Briefing and End-of-Course Appointments — 2

*DENOTES MILITARY TRAINING

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
J3ABR56631 000	IV	11	12 May 86 (Chg)	87

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2TPT-5120-03

TECHNICAL TRAINING

BASIC PHYSICS - MATTER

April 1967

SHEPPARD AIR FORCE BASE

Original Material Prepared
by
Naval Air Technical Training Command

Designed For ATC Course Use

ASSIGNMENT SHEET

This assignment sheet should be used when:

- You are to complete only a part of this text.
- Your assignment within this text is divided into two or more reading periods.

Your instructor will make assignments by identifying specific objectives, text material, and review questions.

ASSIGNMENTS

OBJECTIVES (by No)	TEXT MATERIAL (by Page)	REVIEW QUESTIONS (by No)

MATTER

OBJECTIVES

1. Write the definition of matter.

2. List the three states of matter.

3. Identify the states of matter from a given list of diagrams which show the transfer of each state of matter from one container to another.

4. Match the terms volume, mass, universal attraction, weight, density, inertia, porosity, impenetrability with a list of statements describing these terms.

5. Draw the "Magic Circle" for weight, volume, and density; and write the formula for finding:
   a. weight
   b. volume
   c. density

6. Match the terms element, compound, molecule, and atom with a list of statements describing these terms.

SUGGESTED READING TIME 57 MINUTES

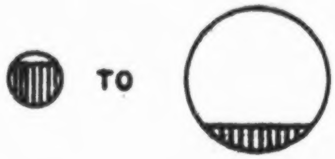
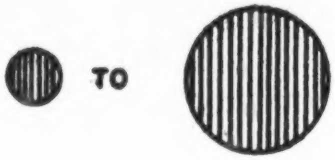
	1. The earth and the planets, or anything that can be found on or in them, take up space and have weight (a vacuum does not have weight). These things are called matter. Matter is anything that has weight and occupies ____________________.
SPACE	2. The pencil you are writing with has weight and occupies space. The pencil, therefore, is considered ____________________.
MATTER	3. You are surrounded by matter. The air you breathe, the food you eat, your own body are all matter. These things and anything that has weight and occupies space are called ____________________.
MATTER	4. The definition of matter is anything that ________ ____________ and ____________ __ __________.
HAS WEIGHT OCCUPIES SPACE	5. What is the definition of matter? ________________________________ _____ ________________________________ _____ CONTINUE ON PAGE 3

(From page 6A)
2A

You will be embarrassed when you return to page 6A and look at the diagram you said represents a solid. Go back now and think about your choice. You will find that it does not have the properties of a solid. Choose the correct one and continue the program.

(From pages 4A or 6B)
2B

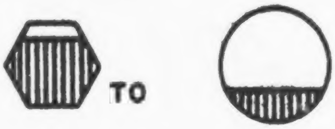
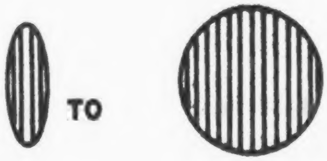
Good. You know how liquids react and look when transferred from one container to another. Gases will react in a certain way, too. They will assume the shape and the volume of a new container, as shown by helium being blown into a balloon. A set of diagrams showing the transfer of gas from one container to another would look like:

If your answer is:	Turn to page:
	4B
	6A

ANYTHING THAT HAS WEIGHT AND OCCUPIES SPACE.	6. Matter exists as a solid. It also exists as a gas and a liquid. The three states in which matter exists are __________, ______________, and __________.
SOLID LIQUID GAS	7. Water, blood, and gasoline are liquids. Steel, wood, and ice are solids. Oxygen, CO_2, and water vapor are gases. Gases, solids, and liquids are the three __________ of __________.
STATES MATTER	8. What are the three states of matter? 1. ____________________ 2. ____________________ 3. ____________________
SOLID LIQUID GAS	9. Each state of matter behaves differently when moved from one container to another. When the gas from a can of "Spare Tire" is released into a tire, it occupies the volume and assumes the shape of the tire. If milk is poured from a pint bottle into a quart pan, will the liquid assume the shape and the volume of the pan? If your answer is: Turn to page: Yes 4A No 6B

(From page 3, frame 9)
4A

Incorrect. It does not assume the volume of the pan. If you pour the milk (1 pint) into the pan (1 quart), will it fill the pan? Of course not, but it will assume the shape. This is the way liquids react in the transfer process. They assume the shape but NOT the VOLUME. The transfer of liquid shown as a diagram would look like:

If your answer is:	Turn to page:
	2B
	8A

(From page 2B)
4B

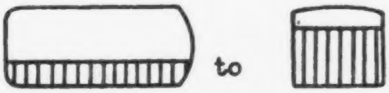
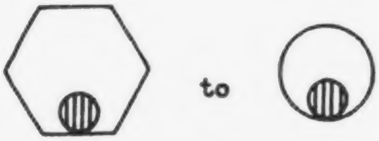
Gas will take up the entire space and assume the shape of the new container when transferred. Return to page 2B and look at the diagrams; see which set of diagrams represents a gas and then turn to the correct answer page.

	10. You are not reading what you should be! If you had followed instructions, you wouldn't be reading this frame. Return to frame 9 and continue the program.
ANSWER TO 20A $W = DV$ $D = \frac{W}{V}$ $V = \frac{W}{D}$	**(From page 20A)** 11. An ELEMENT is a substance that cannot be reduced to simpler substances by chemical means. Gold, oxygen, and platinum cannot be reduced to simpler substances by ____________________ means because they are ______________________.
CHEMICAL ELEMENTS	12. A substance that cannot be broken down into a simpler substance by chemical means is called a/an ______________________.
ELEMENT	13. Elements are the basic substances that are combined to form the many things that we know as compounds. Water and sugar are examples of compounds because they are a combination of two or more elements. An element cannot be reduced to a __________________ ______________________ by chemical means, and a/an ______________________ is made up of two or more elements.

CONTINUE ON PAGE 7

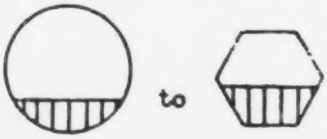
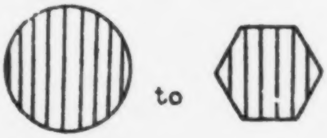
(From page 2B)
6A

Right. You have shown that you know a gas will take the size and shape of a new container if transferred. So far, you know what liquids and gases do when they are transferred from one container to another. Solids react entirely **differently.** They assume NEITHER the shape nor the volume of the new container. Move a block of wood from a small box to the back of a truck. It does not change in shape or volume. Shown as a diagram, transfer of solids would look like:

If your answer is:	Turn to page:
	2A
	10B

(From page 3, frame 9)
6B

Very good. As you have shown, liquids assume the shape of a new container but not the volume (unless the two volumes are the same) This can be shown in a diagram, which might look like:

If your answer is:	Turn to page:
	2B
	13B

SIMPLER SUBSTANCE COMPOUND	14. There are many common things that are elements or compounds. Hydrogen, iron, aluminum, carbon, and tin are all examples of ________________ because it has been found that they cannot be broken down or changed into something simpler (by chemical means).
ELEMENTS	15. Some common examples of compounds are earth, wood, paper, salt, and air. In order to be classed as a compound, the substance must have at least ____________ elements.
TWO (2)	16. Plastic, cotton, and air can all be reduced to a material or substance that is simpler or different, since they are made up of several different elements. They are known as ________________.
COMPOUNDS	17. Matter is made up of very small particles called atoms and molecules. These two small particles are different, since it takes 2 or more atoms to make a molecule. Another way to say it is-- an atom combined with another atom or atoms makes a/an ________________.

CONTINUE ON PAGE 9

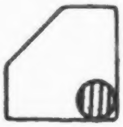
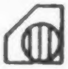
(From page 4A)
8A

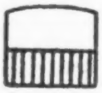
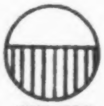
Wrong. The diagram shows that the liquid is assuming the shape and the volume. Liquids will assume the shape and the volume ONLY when the two containers have the same volume . This, of course, is not characteristic of liquids. Go to page 4A and choose the diagrams showing the transfer of liquid from one container to another.

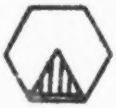
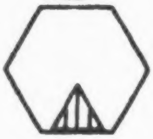
(From page 10B)
8B

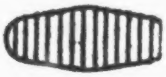
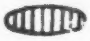
ANSWERS TO PAGE 10B - - a. L, b. S, c. G

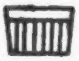
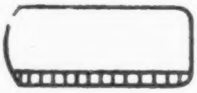
Identify the state of matter in the diagrams below that show the transfer of matter from one container to another. The shaded area represents matter. Fill in the blank between each set of diagrams, using a G for gas, L for liquid, and S for solid.

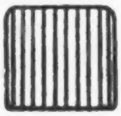
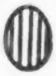
a.  ____ 

b.  ____ 

c.  ____ 

d.  ____ 

e.  ____ 

f.  ____ 

Turn to page 10A

MOLECULE	(From frame 17, page 7) 18. An atom is the smallest particle of an element that can combine with other atoms to form molecules. A molecule is the smallest part of a substance that will have all the characteristics of that substance. The smallest part of water that still has all the properties of water is a/an ____________________.
MOLECULE	19. A molecule will have all the properties of a substance. The particles that make up the molecules and do not necessarily have any of the properties of the substance are called ________________.
ATOMS	20. Remember that a/an __________ does not have to have any of the properties of the substance of which it is a part. The smallest particle of a substance that does have all the properties of it is a/an ____________________. CONTINUE ON PAGE 11A

(From page 8B)
10A

ANSWERS TO PAGE 8B - - a. S, b. L, c. S, d. G, e. L, f. G.

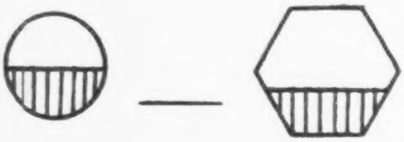
There are several general properties which all matter has in common. These are: volume, mass, universal attraction, weight, density, inertia, porosity, and impenetrability. Would steel have the same general properties as wood?

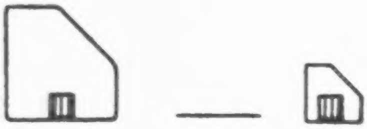
If your answer is:	Turn to page:
Yes	14B
No	12A

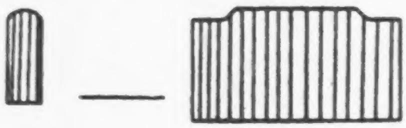
(From page 6A)
10B

RIGHT. As a quick review-- liquids assume the shape but not the volume; gas will take both the new shape and volume; a solid will not change either its shape or its volume. All these transfers from container to container can be shown by diagrams.

Identify the states of matter in the diagrams below. Use G for gas, L for liquid, and S for solid.

a. 

b. 

c. 

Turn to page 8B

(From page 9, frame 20)
11A

ANSWERS TO FRAME 20 - - atom, molecule

Identify each statement below as a description of either an element, compound, molecule, or atom. Write the name in the provided blank.

a. Something that is made up of several different elements.

_____ ____________________

b. A small particle that when combined with other particles of similar size makes a molecule. ________________________________

c. This cannot be reduced to a simpler substance by chemical means. __________________________

d. The smallest part of a substance that retains all the properties of that substance. ____________________________

TURN TO PAGE 14C

(From page 15A)
11B

Very good. Apparently you know how to use the magic circle. Any one of the three properties is just as easy to find. Turn to page 17A to check your understanding of the magic circle.

(From page 13A)
11C

Your answer, water, is incorrect. Remember that density is the weight per unit volume of matter. The density of mercury is 850 pounds per cubic foot, whereas fresh water has a density of 62.5 pounds per cubic foot. In other words, a unit volume of mercury (in this case, a cubic foot) weighs more than a unit volume of water; consequently, mercury is denser than water. Now return to page 13A and select the correct answer.

(From page 10A)
12A

Your answer, no, is incorrect. We said that there were several general properties which all matter has in common. Even though steel and water are different states of matter, they are still matter; and, therefore, have the same general properties. Return to page 10A and select the correct answer.

(From page 14B)
12B

You're right, very good. All matter occupies space; therefore, it has volume. The next general property we will cover is mass. The measure of the quantity of matter in a body is called its mass. The mass of a given body is constant-- it does not vary. As an example of mass, consider a sponge. It contains a definite measurable amount of mass. Whether we squeeze, stretch, or soak the sponge in water, the mass will not change, even though the size and shape may be altered. The amount of sponge will remain unchanged. In other words, the mass of the sponge will remain constant.

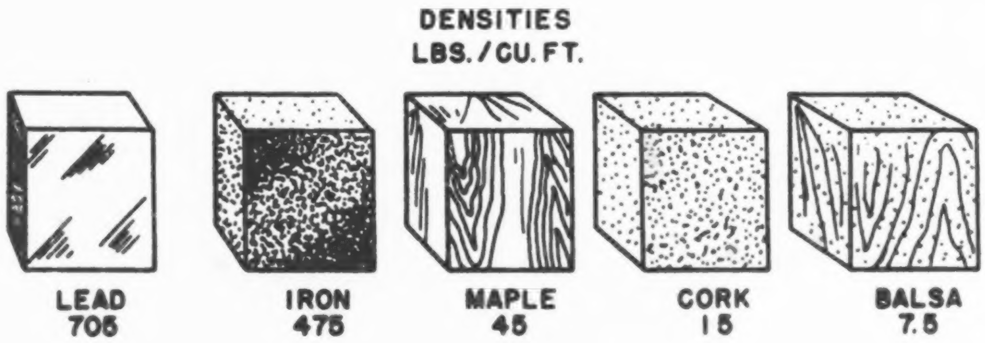
If you squeeze a rubber ball, you are also decreasing its mass.

If your answer is:	Turn to page:
True	18D
False	14A

(From page 16A)
13A

Weight is the attractive force of the earth for a body.

The next general property of matter we will cover is density. Density is the weight of a unit volume of matter. Iron is denser than wood. This means that one cubic foot of iron weighs more than one cubic foot of wood. The more matter (mass) there is in a given volume of a substance, the denser that material is. Shown below are some examples of densities.



Which would be denser, water or mercury?

If your answer is:	Turn to page:
water	11C
mercury	20B

(From page 6B)
13B

Wrong. The diagram shows that the liquid is assuming the shape and the volume. Liquids will assume the shape and the volume ONLY when the two containers have the same volume. This, of course, is not characteristic of liquids. Go back to page 6B and choose the correct answer.

(From page 12B)
14A

You selected false, and you're right. Always remember that the mass of a given body is constant. The next general property of matter we will cover is universal attraction. All matter attracts all other matter. This fact was first stated by Sir Isaac Newton, and it is known as Newton's law of universal gravitation. As an example, the earth is bound to the sun by the mutual attraction of the matter contained in the sun and the earth. Would universal attraction have anything to do with why we are bound to the earth?

If your answer is:	Turn to page:
Yes	16A
No	19B

(From page 10A)
14B

You are absolutely right. We said that the general properties of matter were common to all matter.
Let's now discuss each one of the general properties of matter, starting with volume.
If matter occupies space, as we found it does, it must have length, width, and height. In other words, volume is the measure of the amount of space which matter occupies.
Does gas have volume?

If your answer is:	Turn to page:
Yes	12B
No	15B

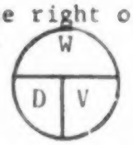
(From page 11A)
14C

ANSWERS TO PAGE 11A: a. Compound Atom c. Element d. Molecule

This completes the program on matter. Review the objectives before taking the self-test.

(From page 16B)
15A

No. You can only put the other two values to the right of the = sign. Thus W=VD. The formula was derived like this---



W = DV

As you notice in the circle, the V and the D are side by side. They are also side by side when they are substituted in the formula. If you want to find the volume or the density, then your formula will change. What is the formula for finding volume?

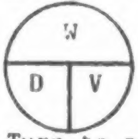
If your answer is:	Turn to page:
$W = DV$	17B
$V = WD$	19A
$V = \frac{W}{D}$	11B

(From page 14B)
15B

Wrong, think again. Doesn't the air, which is a gas, occupy a certain amount of space in a balloon? The CO_2 in a life raft occupies a certain amount of space, doesn't it? The volume of gas is determined by the size of the container in which it is contained and this quantity of volume is measured in cubic units, such as cubic inches, cubic feet, etc. Now return to page 14B and select the correct answer.

(From page 18A or 18C)
15C

Wrong. The formula for finding volume is not V = WD. The magic circle



has the W OVER the D. It would become $V = \frac{W}{D}$.

Turn to page 17A and continue the program.

(From page 14A)
16A

You're right. We are attracted to the earth, as is the earth attracted to us, by universal attraction (gravitation). Of course, the farther away from the earth's surface a body is, the less gravitational attraction there will be on that body.

Now, let's move on to the next general property of matter --- weight. The attraction of the earth for a body acts as a pull on that body. We may say that the earth exerts an attractive force on the body. The measure of the attractive force of the earth for a body is called the weight of the body. As an example, if you weigh 145 pounds, the mass of your body and the mass of the earth mutually attract each other with a force of 145 pounds. Therefore, weight is the ______________________

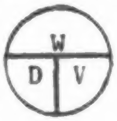
____.

Turn to page 13A

(From page 19C)
16B

Answers from page 19C. -- 1 - G, 2 - E, 3 - F, 4 - A. 5 - B, 6 - C, 7 - D, 8 - H.

Now let me introduce you to the "Magic Circle."



W= Weight
V= Volume
D= Density

There is nothing magic about it, but it does make memory work a little easier. With it, we can find any ONE of three characteristics of matter (volume, density, or weight). You must know two in order to find the third. To do this, take the one you wish to find from the circle and place the letter to the left of the = sign. Then place the other two, just as they appear in the circle, to the right of the = sign. For instance, if you wish to find the weight of an object, take the W out of the circle, put an = sign after it, and place the remaining two known values after the = sign like this:

If your answer is:	Turn to page:
$W = \frac{W}{VD}$	15A
$W = DV$	18A
$W = \frac{V}{D}$	18C

(From page 11B, 15C, 18A, 18C, or 19A)
17A

Right! You should be ready for a test in writing formulas and the magic circle. If you don't feel you can derive a formula from the magic circle, return to page 16C and go through the frames on the magic circle again; otherwise, draw the magic circle and write the formula for finding density.

Magic Circle Formula

Turn to page 18B for answer

(From page 15A)
17B

$W = DV$ is the formula for finding weight, not volume. The unknown must go to the left of the = sign; so, for finding volume, the V goes to the left (V=). Return to page 15A and select the correct formula as you get it from the magic circle.

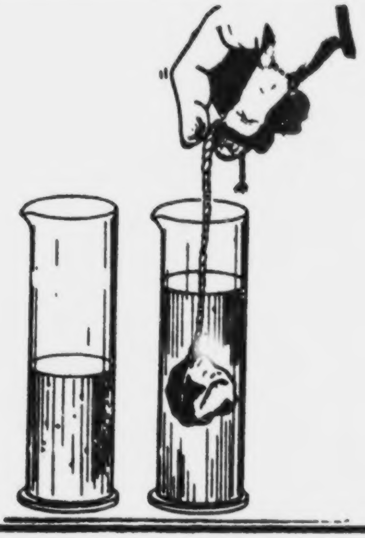
(From page 22A)
17C

Yes, water will seep through a cement block foundation unless the blocks are waterproofed because of the porous nature of cement.

The last general property of matter we will cover is impenetrability. No two objects can occupy the same space at the same time because all matter is impenetrable. A nail driven into a board does not penetrate the wood, but pushes the fibers aside. The drawing shown below illustrates the impenetrability of matter. Explain why. ______________

____

____



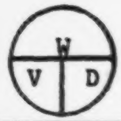
CONTINUE ON PAGE 22B

(From page 16B)
18A

Very good. As you have indicated by your formula, the W is taken from the magic circle and placed to the left of the = sign. The V and the D are side by side. This, of course, means volume times density = weight. If you were going to find the volume of an object, the formula would be:

If your answer is:	Turn to page:
$V = WD$	15C
$V = \frac{W}{D}$	17A

(From page 17A)
18B

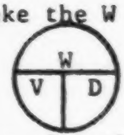
ANSWERS TO PAGE 17A: 

and $D = \frac{W}{V}$

Turn to page 20A

(From page 16B)
18C

No. $W = \frac{V}{D}$ is not correct. If you take the W from the magic circle, to find weight you will have this ---



The V and the D are side by side. It is also that way in the formula. $W=DV$ means weight equals volume times density.

If you want to find the volume of an object, you substitute from the magic circle and have this formula:

If your answer is:	Turn to page:
$V = WD$	15C
$V = \frac{W}{D}$	17A

(From page 12B)
18D

Wrong. Remember, we said that the mass of a given body is constant; it does not vary. By squeezing the rubber ball, all we have done is change its volume. Now return to page 12B and select the correct answer.

(From page 15A)
19A

Draw a magic circle ... Now look at the W and the D. Are they side by side as you indicated in your formula? As you have noticed by now, the W is OVER the D with a line between them. The problem asked for the formula for finding volume. As you take the letters from the magic circle, they will fall right into their proper places and look like this:

$$V= \frac{W}{D}$$

Turn to page 17A and continue the program.

(From page 14A)
19B

Your answer, no, is incorrect. Remember, universal attraction means that all matter attracts all other matter. Therefore, we are bound to the earth's surface by a certain force because of the attraction between our bodies and the earth's surface.
Now return to page 14A and select the correct answer.

(From page 22B)
19C

Match the terms with the statements.

1. Weight________
2. Volume________
3. Mass ________
4. Universal attraction ______
5. Density________
6. Inertia________
7. Porosity_______
8. Impenetrability____

A. All matter attracts all other matter
B. The weight of a unit volume of matter
C. Matter lacks the ability to either start or stop itself.
D. All matter is granular (space between particles).
E. The measure of the amount of space which matter occupies
F. The measure of the quantity of matter in a body. It is constant.
G. The measure of the attractive force of the earth for a body
H. No two objects can occupy the same place at the same time.

CONTINUE ON PAGE 16B

(From page 18B)
20A

Draw the magic circle for weight, density, and volume, and write the formulas for finding weight, density, and volume.

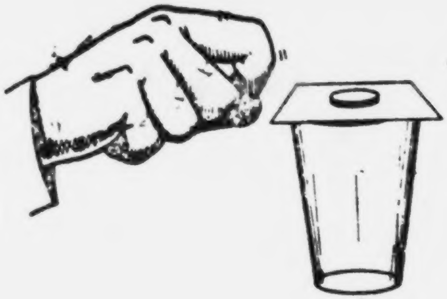
Magic Circle here: Formulas here:

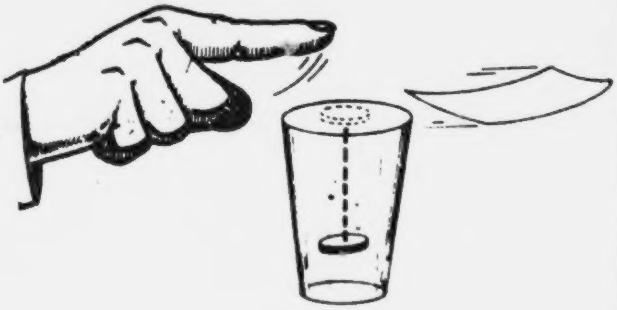
Turn to page 5, frame 11

(From page 13A)
20B

Very good. Mercury is denser than water. Remember, we said that density is the weight of a unit volume of matter. The density of water (fresh) is 62.5 pounds per cubic foot, whereas the density of mercury is approximately 850 pounds per cubic foot.

The next general property of matter we will cover is inertia. According to Newton's law of inertia, a body continues in its state of rest, or uniform motion, unless an unbalanced force acts on it. In other words, matter lacks the ability to either start or stop itself. Some examples of inertia are-- the inability to stop a speeding car when the brakes fail and the inability of an aircraft to make a carrier landing without arresting gear. In the sketch shown below, the inertia of the coin (inability to start itself) allows us to flick the card from under it, and the coin drops directly into the glass.


1.


2.

Would inertia ever be a factor on your body if you were a passenger riding in an automobile? Yes/No ____________

Give an example.____

____

____

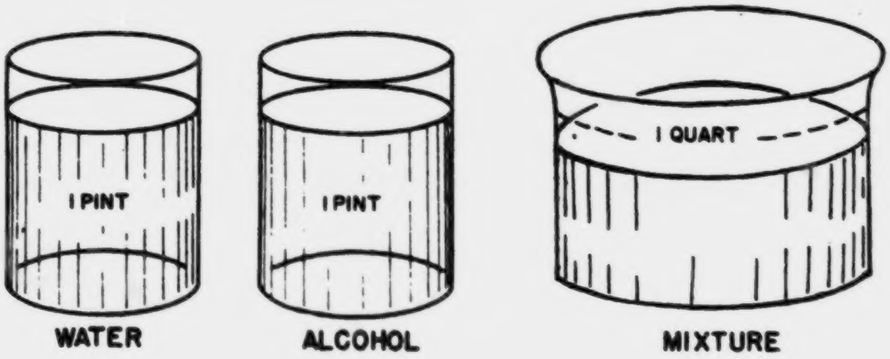
____

Turn to page 21A

(From page 20B)
21A

Yes, it would. An example might be as follows: if you were a passenger riding in a car traveling at 60 miles per hour and the car stopped suddenly, what would be the action of your body if you were not wearing seat belts? According to the law of inertia, a body in motion continues in motion unless acted upon by an outside force. Therefore, your body would be thrown forward and through the windshield. If the car accelerated suddenly, the action of your body would be being thrown against the back of the seat. These are both examples of inertia.

Porosity is the next general property of matter we will cover. All matter is granular, that is, it has space or pores between the particles. The amount of space between the particles depends upon the structure of the material. In the sketch shown below, notice that when a pint of water and a pint of alcohol are mixed, they do not equal a quart of the mixture.

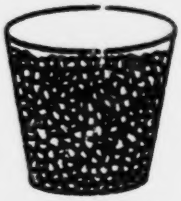


This would suggest that the alcohol partially fills the spaces between the particles of water.

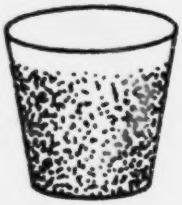
CONTINUE ON PAGE 22A

(From page 21A)
22A

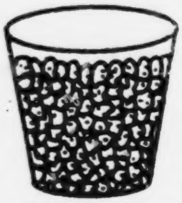
To illustrate the point more clearly, look at the illustration below.



COARSE GRAVEL



SAND



COARSE GRAVEL AND SAND

If we had two similar containers, one filled with gravel and one filled with sand, and if both of these containers were emptied into a larger one, the container with the sand and gravel mixture would not be completely full, because the sand would fill the spaces between the gravel. Could water seep through the cement foundation of a house? Yes/No

Why?

Continue on page 17C

(From page 17C)
22B

Impenetrability of matter is shown in the illustration because the water level rises. The object being lowered into the water takes some of the water's space, which indicates that no two objects can occupy the same place at the same time.

Continue on page 19C

SELF-TEST

MATTER

1. Write the definition of matter.

____

____

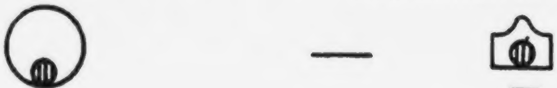
2. List the three states of matter.

    1. ____________
    2. ____________
    3. ____________

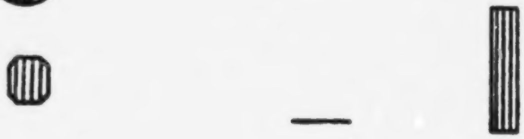
3. Identify the state of matter by writing a G for gas, S for solid, and L for liquid in the spaces provided between each set of diagrams, showing the transfer of states of matter from container number 1 to container number 2. The lined area represents the space occupied by matter.

CONTAINER NO. 1 **CONTAINER NO. 2**

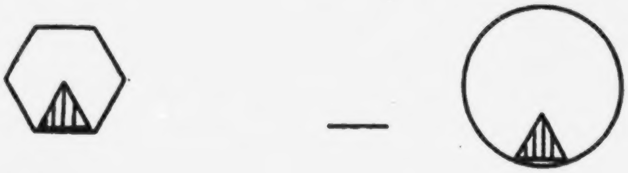
a. ___



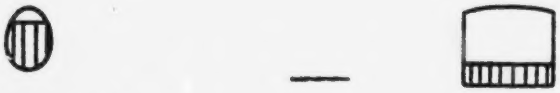
b. ___



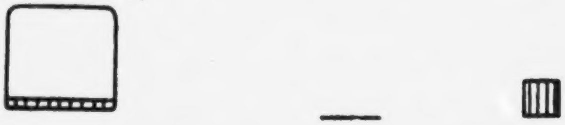
c. ___



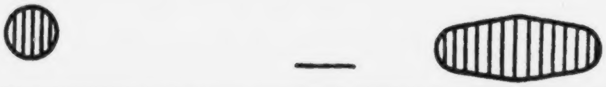
d. ___



e. ___



f. ___



4. Match the terms volume, mass, universal attraction, weight, density, inertia, porosity, and impenetrability with the list of statements describing these terms.

1. Weight _____
2. Volume _____
3. Mass _____
4. Universal attraction _____
5. Density _____
6. Inertia _____
7. Porosity _____
8. Impenetrability _____

A. All matter attracts all other matter.
B. The weight of a unit volume of matter.
C. Matter lacks the ability to either start or stop itself.
D. All matter is granular (space between particles).
E. The measure of the amount of space which matter occupies.
F. The measure of the quantity of matter in a body. It is constant.
G. The measure of the attractive force of the earth for a body.
H. No two objects can occupy the same place at the same time.

5. Draw the "Magic Circle" for weight, volume, and density, and write the correct formula for finding each of them.

Weight ---- Draw the magic circle here

Volume ----

Density ---

6. Identify each of the following phrases or statements as an element, compound, molecule, or atom. Place the correct name in the space provided below **the statement.**

a. Matter that contains several different elements.

____

b. The smallest particle of an element that can combine with other particles to form molecules.

____

c. Water, trees, dirt, and snow are all examples of

______________________________.

d. Gold, hydrogen, and mercury cannot be reduced to a simpler substance by chemical means. They are known as

______________________________.

e. A substance that is broken down to the smallest particle possible and still retains all the properties of that substance is a/an

______________________________.

f. Each particle that combines with other particles to form a molecule is called a/an

______________________________.

g. Matter that cannot be reduced to a simpler substance by chemical means is known as a/an

______________________________.

STUDY GUIDE/WORKBOOK
J3ABR56631 000-I-1 thru 10

Technical Training

Environmental Support Specialist

ENVIRONMENTAL FUNDAMENTALS AND SUPPORT EQUIPMENT

June 1986

3700 TECHNICAL TRAINING WING
3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

DESIGNED FOR ATC COURSE USE

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Study Guide/Workbook J3ABR56631 000-I-1 thru 10

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ACKNOWLEDGEMENT

Preparation of Unit I-9 of this study guide/workbook was aided through the cooperation and courtesy of the Watts Regulator Co., CLA-VAL Co., and FEBCO Sales, Inc. These companies furnished the technical information and illustrations pertaining to the installation, operation, testing and maintenance of the backflow prevention devices. Permission to use their publications is gratefully acknowledged.

Supersedes SW J3ABR56631 000-I-1 thru 10, February 1986

3770 Technial Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

SW J3ABR56631 000-I-1

COURSE ORIENTATION

OBJECTIVE

This study guide/workbook will acquant you with the course organization, contents, objectives, instruction and measurement program, and course, branch and group policies.

INTRODUCTION

This orientation study guide is an introduction. In it, we will try to introduce you to the contents, policies, and objectives of the course for which you have been selected. In our instruction, we will cover the daily schedules, the instruction and measurement policies, the type of training materials used and other items of interest to you as an entering student. Above all, we want you to feel welcome in our course and we will do everything we can to make your stay at Sheppard worthwhile and pleasant for you. The more you put into the course, the more you will get out of it.

Materials presented in the following pages will be under the major topic headings as follows:

- AIR FORCE CAREER PROGRAM DN CAREER ADVANCEMENT
- COURSE ORGANIZATION
- COURSE OPERATING POLICIES, ALERT PROCEDURES, AND MEASUREMENT AND GRADING PRACTICES
- HIGH PERFORMANCE STANDARDS AND HONOR GRADUATE PROGRAM
- INSTRUCTIONAL METHODS AND TRAINING LITERATURE USED IN THE COURSE
- STUDY SKILLS AND STUDENT NOTEBOOK
- ACCIDENT PREVENTION AND SAFETY
- STUDENT CRITIQUE PROGRAM
- FRAUD, WASTE AND ABUSE
- SEXUAL HARASSMENT

AIR FORCE CAREER PRGRAM AND CAREER ADVANCEMENT

INFORMATION

To effectively accomplish the mission of national defense, the Air Force has grouped many jobs and duties into many different career fields. Some of these career fields (or the personnel in these career fields) take care of food service, pay, transportation, personnel records, aircraft maintenance, communications, and many other jobs necessary to the Air Force Mission.

You have been assigned into one of the career fields which support Air Force Civil Engineering activities. Air Force Civil Engineering has the responsibilities for the procurement, operation, and maintenance of base property in general. This property includes land (grounds); roads; buildings; water supply, sewage, electrical, air conditioning, and heating systems; airfield runways and runway lighting systems; and other utilities and faciliites required to keep a base opreationa and to make it a safe, healthful place to work. Three career fields which are regarded as civil engineering are the mechanical/electrical, the construction, and the sanitation (the one you are in) career fields.

Sanitation Career Field (56)

This career field (called the 56 career field), in which you are now assigned, includes the specialties responsible for the operation and maintenance of water and wasteawter equipment and systems. The specialties within this field are Environmental Support (yours) and Entomology. The 56 career field is by far one of the more interesting career fields in which to be assigned.

The above general summary of Civil Engineering career fields has been given so that you will have a knowledge of other specialities in Civil Engineering. The details of your career field are provided in SG J3ABR56631 000-I-2, Career Field Progression and Training. Study it very carefully. It will help you understand the importance of your job. Success in any job depends upon a thorough understanding of that job.

Importance of your Job

To realize the importance of your job as an Environmental Support Specialist, all you have to do is to stop and think a moment about all the uses of water. The foods we eat today--meats, fish, poultry, fresh vegetables, and fresh fruits--simply would not be available without water. Also, critical medicines which are used in hospitals every day could not be prepared without safe, clean water. Can you imagine what it would be like to need a drink of water and not know if it was safe to drink?

A safe water system needs a lot of equipment and all of it requires installation, servicing, maintenance, and operation. From this, you should be able to see the importance of your job both while you are in the service and after you return to civilian life.

Your job is not only one in which it is interesting to work, it is also one in which the pay and prestige in civilian life makes it well worthwhile. Water in our country and the entire world is gradually becoming more and more polluted. People with your training will be in constant demand to purify this water.

A real opportunity is before you, so make the most of it. Both you and the nation will profit from your good work. We will help you every stop of the way. Just let us know when you need help.

Benefits Gained from Course Completion

By now, you should be able to see all the benefits you can gain by completion of this course. These benfits can be summarized as the completion of an activity started, an interesting and important position while in the service, an important and well-paying job upon your return to civilian life, and last but not least, a direct and important contribution to the security of our country. All of these benefits are worth a lot of hard work on the part of each of us.

Consequences of Course Failures

This is one aspect of your Air Force experience that we don't like to think about. Most of us have a strong desire to successfully complete any undertaking we begin. The same way with the course in which you have been enrolled. It is to your best interest to work as hard as you can to complete the course. It should become a matter of pride to be successful in your undertaking.

If you should fail, after all the efforts you and the instructors put forth, you would most likely be reassigned to a career field with lower entrance requirements and one which is less technical. This means, of course, that even if you fail the course, through no fault of your own, you are still in the Air Force and will be reassigned to some other specialty.

If you should fail and the elimination board determines it to be your fault because you did not apply yourself or from some other unsatisfactory action on your part, you could receive disciplinary action. As we said before, this is an aspect we don't like to talk about, so just apply yourself and don't fail.

Career Advancement through OJT

OJT means on-the-job training. This is the part of your career development where you really learn to do by actual work on the job. At the same time, you will be able to expand your knowledge by self-study.

Upon graduation from the course you are now enrolled in, you will be awarded a 3-skill level Air Force Specialty Code (AFSC). Specifically, you will be awarded AFSC 56631, (remember the 56), Apprentice Environmental Support Specialist. You will then be ready to gain the job performance experience and the knowledge you need to advance to the 5-skill level which is the journeyman or specialist level.

Your OJT program will consist of what you may consider as three distinct parts: work, study, and record keeping.

When you report to your organization of assignment, you will be assigned to an OJT trainer. This trainer will enter you on OJT and will mark a copy of the specialty training standard (STS) to show the items for which you are to be trained. This training standard, STS 566X1, lists the knowledge and skill levels you must acquire before being awarded the next higher AFSC. An AF Form 623, On-the-Job Training Record, will also be filled out for you. In this training record, your trainer will keep the STS, which shows the progress you make during your OJT. He will also enter a record of all other training you get, and give you periodic tests to see that you are developing the skills and task knowledge you need for progression to the 5-skill level.

In addition to the OJT you get by doing actual work, you will also be enrolled in the career development course (CDC) for your specialty. In your case, it will be CDC 56651, Environmental Support Specialist. The CDC is a self-study course. You will be tested on the CDC course, as well as the on-the-job performance part of your training. When you have successfully completed both parts of your training, the actual on-the-job work and the CDC, you will be eligible for award of the 5-skill level.

Academic Credits for Course Completion

The American Council of Education receives copies of the course control documents for the course you are in, and all other courses of this type. They have evaluated these control documents and have arrived at the academic credits which can be granted for successful course completion. The number of semester hours credit for this course is given in a catalog issued by the Community College of the Air Force. By the time you leave the service, you will be able to apply a number of semester hours of credit to a related field of study at most educational institutions. At present, this course is valued at 11 semester hours.

COURSE ORGANIZATION

This course is set up to present the instruction in a step-by-step sequence. That is, fundamentals and principles are presented first and are followed by performance to insure that you acquire both the knowledge and skills you need to do your job as an apprentice in the 566X1 field.

Course Content

This course is 320 hours or 8 weeks in length. It is divided into four blocks of instruction. A breakdown of the course subjects is listed below:

Block I, Environmental Fundamentals and Support Equipment

- Course Orientation
- Career Ladder
- Civil Engineering Management
- Security (OPSEC)
- Technical Publications
- Safety Program and Accident Prevention

  - Corrosion Control
  - Hand and Special Tools
  - Operation and Maintenance of Water and Wastewater Treatment Support Equipment
  - Pump and Equipment Maintenance
  - Written Test and Test Critique
- Block II, Water and Wastewater Analysis
  - Related Mathematics
  - Principles of Physics
  - Principles of Chemistry
  - Laboratory Safety
  - Collecting Water and Wastewater Samples
  - Water Analysis
  - Wastewater Analysis
  - Written Test and Test Critique
- Block III, Water Supplies and Treatment
  - Water Well Operation and Maintenance
  - Water Treatment Process
  - Monitor/Operate and Maintain Water Treatment Plant Equipment
  - Monitor/Operate and Maintain Ion Exchange
  - Monitor/Operate and Maintain Electrodialysis Demineralizer Unit
  - Field Water Purificaiton Units
  - Swimming Pools
  - Written Test and Test Critique
- Block IV, Wastewater Treatment and Disposal
  - Characteristics of Wastewater
  - Wastewater Plant Safety
  - Pollution Control Policies and Programs
  - Operation and Maintenance of Septic Tanks
  - Operation and Maintenance of Pretreatment Units
  - Operation and Maintenance of Preliminary Treatment Units
  - Operation and Maintenance of Primary Treatment
  - Operation and Maintenance of Secondary Wastewater Treatment
  - Tertiary Treatment and Disposal
  - Disinfection Process

Logs and Reports

Written Test and Test Critique

Course Critique and Graduation

The sequence of instruction has proven to be very effectie. Many students have completed this course in its present form. You can also successfully complete it. It will require much effort on your part, but then anything worthwhile requires effort.

Organizational Structure

For any large group of people to work together effectively, an organization must be established. This course is no exception, and here the operation must be effective to accomplish the mission of technical training.

This organization is simple. All courses are assigned to training branches. The training branches are in turn a part of the 3770 Technical Training Group. This training group is one of several training groups that make up the 3700 Technical Training Wing. The organization structure of the 3770 Technical Training Group is illustrated in Figure 1-1.

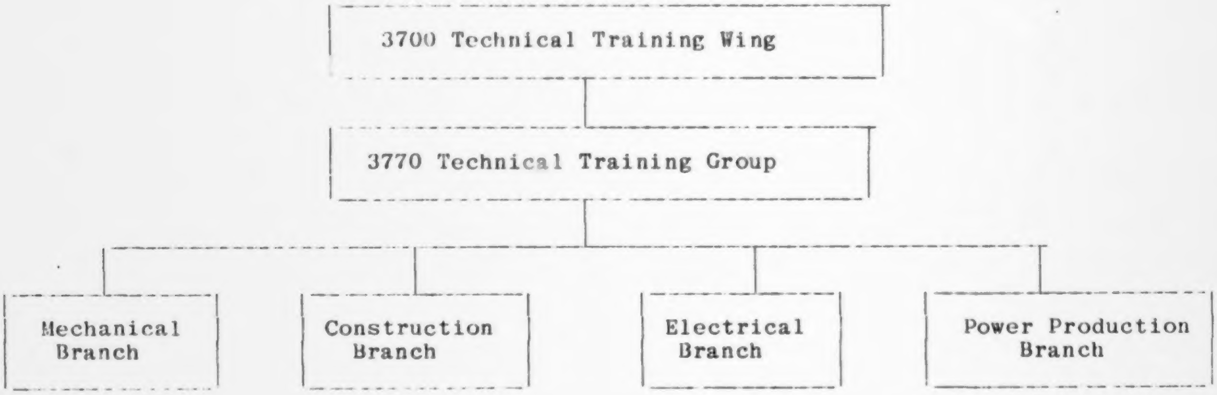

3700 Technical Training Wing
3770 Technical Training Group
Mechanical Branch
Construction Branch
Electrical Branch
Power Production Branch

Figure 1-1. Group Organizational Chart

Figure 1-2 shows a simple straight line chain from you to the group commander. The group commander is responsible to the wing commander, who, in turn is responsible to the training center commander. What this means to you is that while you are in school, the instructors are your immediate supervisors. They will help you in any way and will arrange for you to meet one of the higher level supervisors or chiefs if the need should arise.

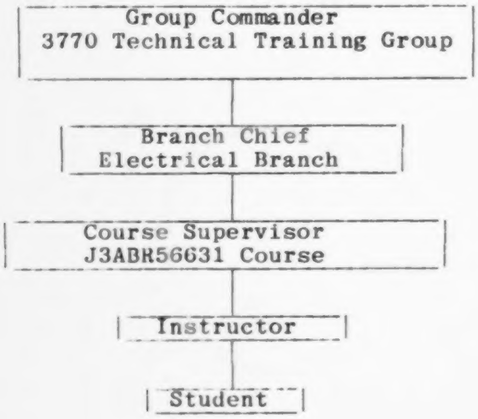

Group Commander
3770 Technical Training Group
Branch Chief
Electrical Branch
Course Supervisor
J3ABR56631 Course
Instructor
Student

Figure 1-2

The Instructor-Supervisor coordinates all course activities with personnel at the Branch and Group. He ensures that training is conducted as set forth in course outlines and directives. He is also responsible for assigning instructor personnel to teach each unit of the course.

You will be taught by both military and civilian instuctors who have as their primary goal, student learning. You should take full advantage of each instructional period by participating in class discussion, take notes, and asking questions.

Course Objectives

The learning objectives for the course are called "Criterion Objectives." You must satisfactorily accomplish these course learning objectives to graduate. A brief explanation of these objectives is as follows:

A Criterion Objective is defined as: "The specification of the behavior which leads to or satisfies a job performance requirement or standard." Simply stated, for each element of training which you must do in this course, there will be a criterion objective. You must do all of these criterion objectives. The instructor or supervisor will sign off the objectives on a Criterion Checklist as you do them. He/she must show all criterion objectives as being done before he gives you a measurement test. You will not be given a test for advancement to the next block or unit of instruction until you have done all the objectives for the unit in which yu are assigned. Additional instruction will be provided if you need it; hard work and study on your part are very important.

Your instructor must determine the progress you are making toward acquiring the knowledge and skill needed to do the course criterion objectives. The instructor will check your attainment of this knowledge and skill by observing your work; checking your completed workbooks; giving you oral or written quizzes; having you do special projects; checking your notebook, and finally by administering a written measurement test.

COURSE OPERATING POLICIES, ALERT PROCEDURES AND MEASUREMENT AND GRADING PRACTICES

Training Schedule

This course operates on "S" shift. The shift starts at 0600 hours and ends at 1500 hours. Student training activity is scheduled as follows:

0600 - 0610	Class Preparation
0610 - 0710	Instruction
0710 - 0725	Break
0725 - 0825	Instruction
0825 - 0830	Break
0830 - 0930	Instruction
0930 - 0945	Break
0945 - 1045	Instruction
1045 - 1050	Break
1050 - 1150	Instruction
1150 - 1300	Lunch
1300 - 1400	Instruction
1400 - 1410	Break
1410 - 1450	Instruction
1450 - 1500	Cleanup/dismissal

This course will also operate on "T" shift, only if there is a double-class entry. The shift starts at 1500 hours and ends at 2400 hours. Students' training activity is scheduled as follows:

1500 - 1510	Class Preparation
1510 - 1610	Instruction
1610 - 1625	Break
1625 - 1725	Instruction
1725 - 1835	Lunch
1835 - 1935	Instruction
1935 - 1940	Break
1940 - 2040	Instruction
2040 - 2055	Break
2055 - 2155	Instruction
2155 - 2200	Break
2200 - 2300	Instruction
2300 - 2310	Break
2310 - 2350	Instruction
2350 - 2400	Cleanup

This is the normal schedule for classroom instruction. This schedule may vary slightly due to field trips, inclement weather, missing schedules and so forth.

Breaks

Break schedules are posted on each classroom bulletin board. Your instructor will dismiss you for breaks and designate the break area you should use - breaks will normally be taken outside. The inside break area may be used during inclement weather. All students must leave classrooms for the entire break period.

Facilities are provided for you to buy gum, candy, beverages, and so forth. In order to minimize fire hazards, your cigarette butts will be placed in butt cans (painted red) and trash placed in proper containers. Each student is responsible for keeping the break area clean. No smoking is allowed in the inside break area.

Be sure to stay in the break area during break, do not loiter on sidewalks or in front of doors, and be certain to obey all signs and follow the directions of the break monitor. Most of all, be sure and take your break, leave the classroom, and relax.

Cleanup Responsibilities

All areas of isntruction must be kept clean, therefore, it will be your responsibility to do the cleanup assigned. During your tour of the course instructional areas, your instructor will show you where all cleaning supplies are located. The authorized cleanup time is 10 minutes prior to dismissal. To do a good job, cooperation is mandatory of all personnel.

Uniform for Attendance and Military Appearance

The uniform worn to school is prescribed by the base commander in accordance with AF regulations. Your uniform for this course is fatigues (long or short sleeves), fati caps, and brogans. Your squadron will be notified by the commandant of troops on a daily basis of any change in wearing apparel. All students will have clean, pressed fatigues and shined shoes, and be well groomed. Any discrepancies noticed by the instructor will be reported to the supervisor for corrective action.

Sick Call

Procedures for reporting to sick call will be discussed by your squadron taining personnel. Should you become ill when in the classroom, inform the instructor of the nature of your illness. Arrangements for transportation to the base hopsital will be made by the instructor if necessary.

Absence from Class

You may be excused from class for legitimate reasons; however, it is desirable that your personal affairs and appointments be conducted so as not to interfere with school.

Your squadron will be notifed within two hours to determine the cause of your absence if you miss the class roll call.

Emergency Leave Procedures

Inform your parents that they should contact their local Red Cross in case of serious illness or a death in your immediate family. In turn, the Red Cross will notify you through your squadron, and if emergency leave is warrented, arrangements will be made for a speedy departure.

COURSE POLICIES

Certain procedures to be followed by course personnel are referred to as course policies. Be sure you thoroughly understand these policies.

Selection of Class Leader

Technical School regulations require each class entering training to have a class leader. The course supervisor will select one student from each class to serve as "Class Leader" during those periods when students are in training. The duties and responsibilities of the class leader according to ATC Regulation 52-15 are as follows:

a. Insure that students enter and leave the classrooms in an orderly manner.

b. Assume control of the class in the absence of the instructor or as directed.

c. Encourage students to assume proper attitudes toward instructors, course supervisors, course policies, instructional material, and all other problems which tend to affect the morale of students.

d. Act as class spokesman.

e. Encourage the class to maintain a high standard of military bearing, neatness and appearance at all times.

f. Assist responsible personnel in supervising cleanup and other details requiring participation by the class.

Student Conduct

While attending this course, student conduct will be of the highest caliber. Profanity and horseplay will not be tolerated at any time. Students who do not display proper conduct may be eliminated from the course.

Fire Alarm and Alert Procedures

Fire evacuation plans and alert procedures are posted in each classroom on the bulletin board. The instructor will brief you on evacuation procedures and reassembly location.

The instructor will also brief you on the alert signals used in storm warnings and for drills required by simulated or actual attacks by enemy forces. He will inform you of the location of your fallout shelter and the evacuation procedures to be used. To reinforce what he tells you, locate alert warning procedures on your school and squadron bulletin boards and become familiar with the required procedures. It is a poor time to study the fine print when fact to face with a Texas tornado or an enemy attack. Be prepared.

Measurement and Grading Practices

Briefly stated, your progress will be measured in two ways; the Criterion Progress Check and the Written Test. Since you must complete all criterion objectives for a unit of instruction prior to being given the measurement test, the instructor will make a continuing assessment of your progress in accomplishing the criterion objectives. He will watch your performance to insure that you complete all workbooks, and he may give you a short quiz to satisfy himself that you have done each criterion objective. When he is satisfied with the results of these criterion progress checks, he will sign off on the criterion checklist that you have done the criterion objective in question. When you have done all the criterion objectives in a given unit or block of instruction, he will sign off that you are ready for the written test.

The Written Test is an objective type test designed to measure knowledge as applied to specialty tasks. It is used as a record of your progress in the course. The tests you will take may have 50 test items, in multiple-choice form. Remember, your score on these tests will go on your permanent course record. Do the very best you can to make good grades. It is well forth the effort.

The test for a unit or block of instruction normally has at least one queston on each objective. It may have more than one question for each objective but you can expect at least one. The test may cover any aspect of the course: self-study, discussions and demonstrations, and performance of all steps in the workbook exercise.

You must make a score of 60% or above to pass the written (block) tests. If you are well-prepared and have done your work well, you need not be concerned with the minimum grades as you will likely score higher. Written instructions will be furnished you at the beginning of each test period. REad these instructions carefully; they affect YOUR future.

Questions missed on each test will be reviewed (critiqued) by the isntructor and class to help you identify mistakes you made during the test. During these critieuqes, you will not be perfmitted to make notes as the rules for protection of tests are very strict. You will be informed of your test scores as soon as possible after the test period. You probably won't fail any tests, but if you should, you will be given additional instruction and retested or washed back to repeat the unit of instruction.

Counseling, Washback, and Elimination

If you should fail a test, the instructor or supervisor will discuss the failure with you and will counsel you on the best action to take. During these counseling sessions, remember that the instructor or supervisor is interested in your problems. The have nothing against you and are only trying to arrive at the solution to whatever the problem was that caused you to fail. Be honest with them and discuss your problem. The discussion will benefit both of you.

Should you fail a test, two avenues are open: Washback or elimination. Washback simply means you will be assigned to a class behind you so that you can repeat the block in which you failed to make a passing grade. If you fail to pass the test, after you repeat a block, you may be considered for elimination in your best interest or in the best interest of the Air Force.

Proficiency Advancement

This is a program to allow you to be tested on any portion of the course in which you have already had training or experience. In other words, it isn't economical to use time training you in a subject in which you are already proficient. If you should identify a block in the course which contains materials for which you have had good training and for which you feel you can pass the tests, you should apply for proficiency advancement. If you pass all the required tests, you can bypass these materials and graduate ahead of your class.

HIGH PERFORMANCE STANDARDS AND HONOR GRADUATE PROGRAM

The Honor Graduate program is used to reward those students who have shown outstanding academic performance. In short, it is a program which allows for recognition of those students who really apply themselves so that they will get as much as possible from their training.

The top 10 percent of graduates from a course in a year will be Honor Graduates. To be an Honor Graduate, you must complete the course with a high average course grade, and you must have a good record of conduct in both the school and the squadron. Students who have washed back or who have been allowed to continue on probationary basis, due to low grades are not eligible to compete for Honor Graduate. Also, personnel who violate the established rules of good conduct will not be considered.

Those students who earn the Honor Graduate designation are awarded an Honor Graduate Certificate. This special recognition certificate is signed by both the group and wing commanders. It is a certificate you will be proud to receive since it will reflect your own efforts. While the instructors are required to provide you the best possible instruction, the grades required to become an Honor Graduate can only be made by you. Your efforts alone are rewarded when you make Honor Graduate. The certificate will be a recognition of the high standards you have maintained; however, your efforts in accomplishing the course objectives to the best of your ability will also result in your getting top notch training. These extra efforts will serve you well during your tour in the Air Force, and through the rest of your life. Do your best to maintain the very highest standards. Do this for us and also for yourself.

The Community College of the Air Force grew out of efforts to find ways to increase the benefits of Air Force training. The representatives of the US Air Force Academy, Air University and Air Training Command met in February of 1971. They found a way to show and record Air Force training as formal education by starting the CCAF. This helps you by allowing you to get college credits for your Air Force training. You can add to these credits by going to conventional college courses. This will lead to a college degree which shows the level of training you have achieved.

You received 4 semester hours of credit by completing Basic Training. This course will add on 11 more hours to make a total of 15 hours you can apply toward the 64 hours you need for an Associate degree with a major in Environmental Services.

INSTRUCTIONAL METHODS AND TRAINING LITERATURE USED IN THE COURSE

Study guides and workbooks are issued to each student as an aid in understanding the subject matter. The material in these study guides does not include all the materials which you are required to know. The notes taken in class plus the training materials will give you the information you need. At the end of each study guide are questions you must answer. Answer the questions, then return to the text and check your answers. The instructor may pick up and review these questions from time to time.

You will find instructions for performing laboratory or problem-solving tasks in the workbook and in Technical Orders. Before you start a workbook or project, read the whole project and then take each step in its proper sequence. If in doubt, be sure to question the instructor. You must answer questions in the project or at the end of each project.

Programmed Instruction Packages/Texts

These books are a relatively new and scientific approach to learning. Programmed Instruction Packages (PIPs) are a combination of study guides and workbooks which require student response throughout. We think you will enjoy this new way of learning.

Methods of Presenting Course Material

There are several methods used by instructors to insure student understanidng. These include:

LECTURE (Instructor-Centered). A telling lesson. You are expected to be alert, awake, and attentive although no student response is required. Only a small part of the course will be presented as lecture.

DISCUSSION (Student-Centered). The instructor allows the students to express their ideas and opinions as applied to technical problems.

DEMONSTRATION (Instructor-Centered). The student observes as the instructor demonstrates methods and procedures used in operating, disassembling, inspecting, cleaning, and assembling equipment.

PERFORMANCE (Student-Centered). From the instructor's demonstration, you are now expected to complete the work project exactly as shown by the instructor and as directed by the workbook.

STUDY SKILLS AND STUDENT NOTEBOOK

You must do a great amount of study to complete any course if you are to have a good understanding of its content. This is a problem for many of us since we really don't know how to study effectively. To help you overocme this drawback, you will be given a copy of a programmed test on how to study. This text, ATAC Programmed Text 52-11, Study Skills, msut be completed. It will do you more good than you can imagine, so be sure you do it as assigned. Have your instructor check it.

Student Notebook

This item in your education and training must be done by by you. No one else can make an effective notebook for you.

Like everything else worthwhile, making a good notebook takes time and work. Perhaps you can develop a good method for yourself. One effective method is for you to study your study guide assignment and make an outline of the major topics and subtopics, jotting down items which look important to you. This should be in an informal form. After reviewing your study guide assignment and your rough notes, you should be prepared to participate in the classroom discussion of the subject.

During the classroom discussion, you should correct your material as required and add the important items identified by the instructor. You should also add to these notes during your performance exercises. Make sure you get down all the key parts of the training literature and from the instructor's discussions. This is the material you need for good course grades and satisfactory performance in the field.

Once you have everything of importance written in your notes, you are ready to sit down and copy it into your permanent notebook. Now organize your material, and use an ink pen or typewriter to transcribe your notes into a notebook you can retain for later use and reference. Work! Yes, but it is worth it. You won't appreciate a good notebook until later in your career, but it will be worth more than its weight in gold to you.

ACCIDENT PREVENTION AND SAFETY

This is another outstanding Air Force program which is established for the benefit of all of us. The safe, economical accomplishment of our job can only be done by strict adherence to established rules for safety and accident prevention.

The Air Force accident prevention program is covered in a series of publications numbered in the 127 series. This series, Air Force Occupational Safety and Health Program (AFOSH), is the primary guide used in the field for avoiding accidents in our type work. You will become acquainted with his regulation here in the school. You must use it in the field. It is to your advantage and also to the advantage of the Air Force to learn to do your work well and safely.

While in this school, you will be issued a safety guide which covers the more specific items of safety and accident prevention. Study it carefully. Your well-being and the well-being of your fellow workers depends upon how well you learn the lessons of safety. In fact, the safety you learn now will also serve you well when you return to civilian life.

STUDENT CRITIQUE PROGRAM

Air Training Command Regulation (ATCR) 52-29, Student Critique Program, provides the guidance and instructions for administering this program.

The regulation lists the objective of this program as: "The student critique program was established to obtain, from students' constructive criticism of training, the training environment, base support facilities, and services."

You can see why we need a program of this type. We, who work in the school day in and day out, know how the school looks to us. Unless you tell us on your critique form, we will not know how it looks to you. The overall policies for the critique program are as follows:

- You are required to be briefed on the critique program--this study guide will provide some of this briefing.
- You will receive specific instructions upon being presented the end-of-the course critique forms. Generally, critiques are submitted by you on graduation day; however, you may submit on any time you see a need to do so.
- You do not absolutely have to identify yourself on the critique form, but you are encouraged to do so. You can submit a signed critique without fear of prejudice or reprisal. We are interested in obtaining your constructive comments, so don't hesitate to put them down and put your name on the form.
- You may make changes to your critique form before you submit it; however, no alterations may be made after you submit it.
- Your comments are not disclosed to other students. They are entitled to their judgments of the course, as well as you.
- Your critiques are reviewed by personnel responsible for all aspects of the training program. Often we find that students identify things which we may have overlooked.

Your critique of the school and training program will include your appraisal as to the effectiveness of: Instruction, Individual Assistance, Training Methods, Training Literature, Visual Aids, Training Equipment, Written and Practical Tests, Classroom and Training Area, and an Overall Evaluation of the Course. To make sure you are in a position to make worthwhile comments of these elements of the training program, you may want to keep notes at the end of each block. If you keep notes from every block of instruction, you can simply review your notes and complete the end-of-course critique. Remember, we are concerned with constructive comments which can be used to improve training.

In addition to the training critique, you may also complete a form dealing with base facilities and services. The base commander reviews these for ideas for improving the base services. This critique will cover such items as Dining Hall, Club, Recreation, Base Services, Security Police, Base Transportation, Mail, Administration (pay, etc.), Medical, and again Overall Education.

So, once again, keep the notes you need as you go through our course and at the end give us a critique which will be of assistance in improving the training for others who come after you are gone. We will appreciate your help.

FRAUD, WASTE AND ABUSE (FW&A)

Fraud, Waste and Abuse is a multi-billion dollar problem in the Department of Defense. As taxpayers, we whuld all have an interest in the efficient, effective operation of our government agencies. Misuse of Air Force resources detracts from our readiness, and could damage our national security. A responsibility of good citizenship is not only to insure that he/she does not commit acts of fraud, waste, and abuse, but also to report suspected wrongdoing to the proper authorities.

SEXUAL HARASSMENT

The intent of the regulation is not to govern the off-duty activities of Air Force members, or to imply that social inequality exists between all members. The intent is to preserve good order and discipline and thereby enhance operational effectiveness.

It is sometimes extremely difficult to be democratic and disciplined. Simultaneously, in the military, developing a personal relationship with other members can, and often does, prejudice good order. Discipline requires our adherence to published standards of conduct and behavior.

SUMMARY

It has been our aim in this study guide to tell you a little about our school and your job within the Air Force. We hope we have made a good impression on you and hope that you can understand the importance of your position in the Air Force.

The modern Environmental Support Specialist must be a well-trained and highly-skilled person. In civilian life, he is constantly needed. You have been fortunate in having been selected to become this type of technician. It is important to you to study and work hard to take advantage of your opportunity. We will help you as much as possible; however, it is up to you to take care of your future. So work with us, and together we will succeed.

QUESTIONS

In this space we normally present you a listing of questions and ask you to answer them. Since this study guide has been about us, we hope you will ask us some questions. We will try to answer them for you, or we will find you the answers.

REFERENCES

1. Air Force Regulation (AFR) 39-1, Airman Classification Regulation
2. ATC Programmed Text 52-11, Study Skills
3. ATC Regulation 52-3, Student Measurement
4. ATC Regulation 52-29, Student Critique Program
5. Technical School Regulation 50-30, Orientation and Motivational Practices

EXERCISE I-1a

INSTRUCTIONS

Using SW J3ABR56631 000-I-1 and your class notes, fill out the following blanks.

1. Class number and name of course: ____________________

2. Length of course: ____________________

3. Start Date: ______________ Graduation Date: ______________

4. Class hours from ______________ to ______________

5. Course telephone numbers: ____________________

6. Instructor's name: ____________________

7. Building number: ____________________

8. Break schedule:

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

   e. ____________________

9. Smoking area: ____________________

10. Eating and drinking area: ____________________

11. Tornado Shelter: ____________________

12. Nuclear disaster area: ____________________

13. 3770th Technical Training Group Commander: ____________________

14. Electrical Branch Chief: ____________________

15. Environmental Support Course Supervisor: ____________________

16. Minimum passing score: ____________________

3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

CAREER LADDER

OBJECTIVES

Given an extract from AFR 39-1, select information that describes the duties and responsibilities of the 566X1 career field. Four of the five must be correct.

Using the 566X1 career field ladder, list the AFSC titles and the methods of advancing from one step to another. Ten of the fourteen must be correct.

INTRODUCTION

Every person desires to get ahead. We usually want something better in life than what we now have. You can get ahead by advancing in rank. How do you advance in rank? This study guide will help you to understaand what you must do.

This lesson will be divided into three main topics:

- DUTIES AND RESPONSIBILITIES
- CAREER FIELD PROGRESSION
- TRAINING

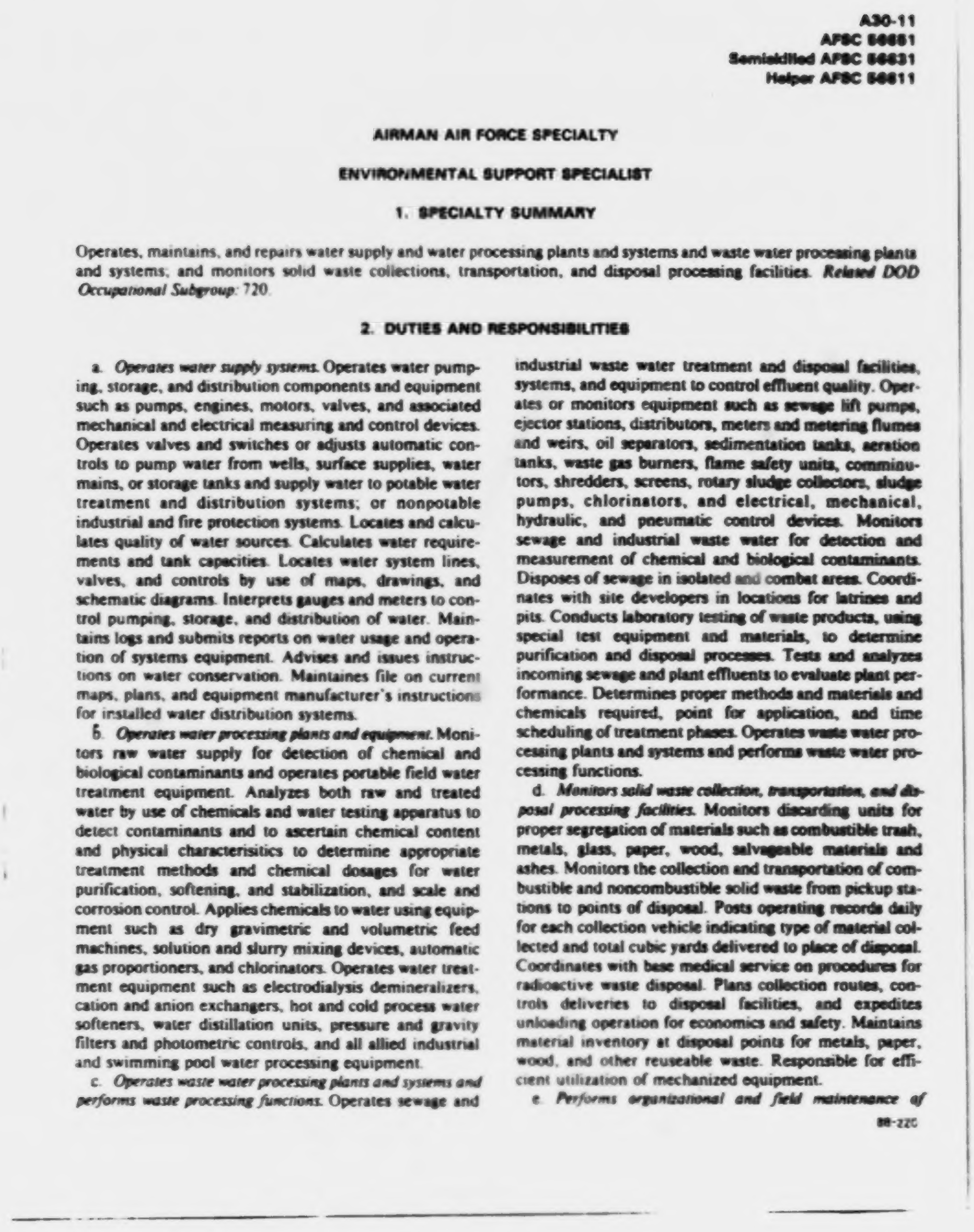
INFORMATION

DUTIES AND RESPONSIBILITIES

Duties of AFSC 56631/51/71

The duties that you will perform as an Environmental Support Specialist are outlined in the specialty description in Air Force Regulation 39-1, Airman Classification Manual.

The 3- and 5-level duties are combined into one specialty description. Your specialty description is shown in Figure 2-1.



A30-11
AFSC 56651
Semiskilled AFSC 56631
Helper AFSC 56611

AIRMAN AIR FORCE SPECIALTY

ENVIRONMENTAL SUPPORT SPECIALIST

1. SPECIALTY SUMMARY

Operates, maintains, and repairs water supply and water processing plants and systems and waste water processing plants and systems; and monitors solid waste collections, transportation, and disposal processing facilities. *Related DOD Occupational Subgroup:* 720.

2. DUTIES AND RESPONSIBILITIES

a. *Operates water supply systems.* Operates water pumping, storage, and distribution components and equipment such as pumps, engines, motors, valves, and associated mechanical and electrical measuring and control devices. Operates valves and switches or adjusts automatic controls to pump water from wells, surface supplies, water mains, or storage tanks and supply water to potable water treatment and distribution systems; or nonpotable industrial and fire protection systems. Locates and calculates quality of water sources. Calculates water requirements and tank capacities. Locates water system lines, valves, and controls by use of maps, drawings, and schematic diagrams. Interprets gauges and meters to control pumping, storage, and distribution of water. Maintains logs and submits reports on water usage and operation of systems equipment. Advises and issues instructions on water conservation. Maintaines file on current maps, plans, and equipment manufacturer's instructions for installed water distribution systems.

b. *Operates water processing plants and equipment.* Monitors raw water supply for detection of chemical and biological contaminants and operates portable field water treatment equipment. Analyzes both raw and treated water by use of chemicals and water testing apparatus to detect contaminants and to ascertain chemical content and physical characterisitics to determine appropriate treatment methods and chemical dosages for water purification, softening, and stabilization, and scale and corrosion control. Applies chemicals to water using equipment such as dry gravimetric and volumetric feed machines, solution and slurry mixing devices, automatic gas proportioners, and chlorinators. Operates water treatment equipment such as electrodialysis demineralizers, cation and anion exchangers, hot and cold process water softeners, water distillation units, pressure and gravity filters and photometric controls, and all allied industrial and swimming pool water processing equipment.

c. *Operates waste water processing plants and systems and performs waste processing functions.* Operates sewage and industrial waste water treatment and disposal facilities, systems, and equipment to control effluent quality. Operates or monitors equipment such as sewage lift pumps, ejector stations, distributors, meters and metering flumes and weirs, oil separators, sedimentation tanks, aeration tanks, waste gas burners, flame safety units, comminutors, shredders, screens, rotary sludge collectors, sludge pumps, chlorinators, and electrical, mechanical, hydraulic, and pneumatic control devices. Monitors sewage and industrial waste water for detection and measurement of chemical and biological contaminants. Disposes of sewage in isolated and combat areas. Coordinates with site developers in locations for latrines and pits. Conducts laboratory testing of waste products, using special test equipment and materials, to determine purification and disposal processes. Tests and analyzes incoming sewage and plant effluents to evaluate plant performance. Determines proper methods and materials and chemicals required, point for application, and time scheduling of treatment phases. Operates waste water processing plants and systems and performs waste water processing functions.

d. *Monitors solid waste collection, transportation, and disposal processing facilities.* Monitors discarding units for proper segregation of materials such as combustible trash, metals, glass, paper, wood, salvageable materials and ashes. Monitors the collection and transportation of combustible and noncombustible solid waste from pickup stations to points of disposal. Posts operating records daily for each collection vehicle indicating type of material collected and total cubic yards delivered to place of disposal. Coordinates with base medical service on procedures for radioactive waste disposal. Plans collection routes, controls deliveries to disposal facilities, and expedites unloading operation for economics and safety. Maintains material inventory at disposal points for metals, paper, wood, and other reuseable waste. Responsible for efficient utilization of mechanized equipment.

e. *Performs organizational and field maintenance of*

88-220

Figure 2-1. Environmental Support Specialist Description

water, waste water, and solid waste processing equipment systems and controls. Assists in major overhaul of above equipment; services power source engines with fuel, oil, coolants, and lubricants. Performs maintenance and repair of water plant and systems components such as pumps, engines, motors, valves, tanks, condensers, cooling towers, chlorinators, fluoridators, and distillation, demineralizing, and softening units. Performs maintenance and repair of liquid waste products plant and systems components such as pumps, ejector stations, distributors, screens, rotary sludge collectors, chlorinators, and wood, metal, masonry, and concrete structures. Locates pipelines, valves, and fittings by use of current maps and electronic locator equipment. Maintains special water and waste products testing and analyzing equipment and materials.

f. *Supervises environmental support personnel.* Instructs subordinates in techniques of operation and maintenance of water, waste water and solid waste processing plants, systems, and equipment. Assigns and monitors work to ensure compliance with local procedures and applicable technical orders.

3. SPECIALTY QUALIFICATIONS

a. *Knowledge.* Knowledge of principles of chemistry and physics that apply to water procurement, purifying, and distribution; and waste products processing and disposal is mandatory. Possession of mandatory knowledge will be determined according to AFR 35-1.

b. *Education.* Completion of high school with courses in chemistry and biology is desirable.

c. *Experience.* Experience in functions such as the operation of water supply and distribution systems; waste products testing, and analyzing equipment and materials is mandatory.

d. *Training.* Completion of a basic environmental support course is desirable.

e. *Other:*

(1) A minimum of Grade I color vision as defined in AFM 160-17 is mandatory.

(2) Physical qualification for military drivers according to AFR 160-43 is mandatory for entry into this AFSC.

88-221

Figure 2-1. Environmental Support Specialist Description (Continued)

EXERCISE I-2-2a

INSTRUCTIONS

Use SW J3ABR56631 000-I-2 and list at least 4 duties of the following AFSCs.

1. 56631/51

a. ____________________

b. ____________________

c. ____________________

d. ____________________

2. Name other types of jobs under the 56 career field.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

3. What Air Force Regulation gives the duies of an Environmental Support Specialist?

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

CAREER FIELD PROGRESSION

What is a career field? A career field includes all similar or related Air Force specialties. Each career field is made up of certain types of work that people are assigned to do. For instance, airplance mechanics are in a certain career field; so are plumbers. You have been assigned to the Sanitation Career Field.

Why do we need career fields? The career field puts the right person in the right job. It also allows the Air Force to set up specific training programs for each career field. A career field also allows the Air Force to list the duties for a specialty which prevents overlapping of jobs and unfair promotions.

Every career field in the Air Force is given a number. If you were a cook, your career field number would be 62. If you were an airplane mechanic, you would be in the 43 career field. Your career field number is 56.

Air Force Specialty Code (AFSC)

The Air Force Specialty Code (AFSC) is made up of five numbers. Every person in the Air Force has an AFSC. You have one. We will explain the meaning of your AFSC in the next few paragraphs. Since you are assigned to Sanitation, your first two digits are 56.

When you were in basic training, your AFSC was 99000. At the present time, you are classified as a sanitation helper, and your AFSC is 56611. This AFSC indicates that you have not yet been trained to do a job.

When you graduate from this course, you will be awarded your 3-level AFSC. It will be 56631. Notice that the next to last number changes from a 1 to a 3. This change means you have learned a trade and are qualified to do some of the work in that trade.

After you have worked in the field for awhile and have also completed some additional training you will be awarded a 5-level AFSC. This means you will qualify to work on more complicated equipment and will do many jobs without someone helping you. The next step is the 7-level and then the superintendent 9-level. Figure 2-2 shows a picture of the career field ladder and AFSC breakdown.

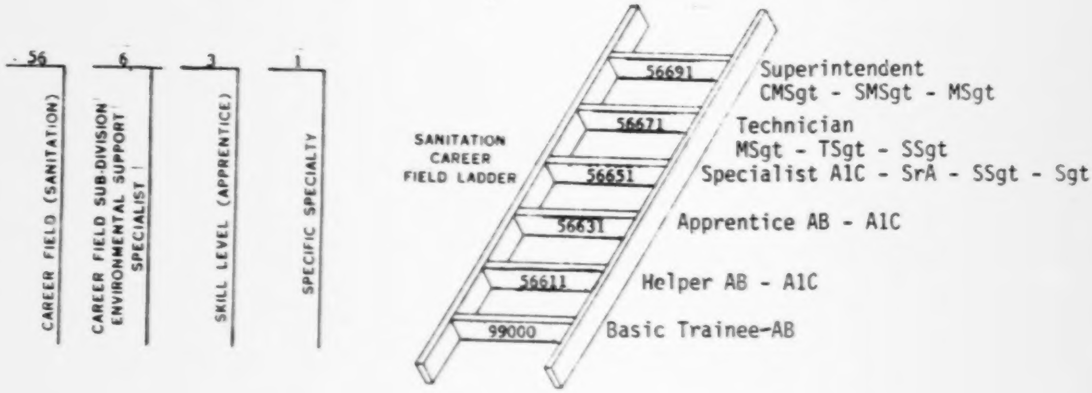

56
6
3
1
CAREER FIELD (SANITATION)
CAREER FIELD SUB-DIVISION ENVIRONMENTAL SUPPORT SPECIALIST
SKILL LEVEL (APPRENTICE)
SPECIFIC SPECIALTY
SANITATION CAREER FIELD LADDER
56691
Superintendent CMSgt - SMSgt - MSgt
56671
Technician MSgt - TSgt - SSgt
56651
Specialist A1C - SrA - SSgt - Sgt
56631
Apprentice AB - A1C
56611
Helper AB - A1C
99000
Basic Trainee-AB

Figure 2-2. Career Field Ladder and Breakdown of AFSC 566X1

Career Field Chart

In the sanitation career field, there are two different types of work that carry the 56 number. One is Environmental Support Specialist and the other is Entomology. An entomologist keeps a base free of flies, mosquitoes, and all types of insects as well as pests such as mice and rats, and undesirable vegetation.

Figure 2-2 is a chart showing progression in each 56 career field ladder.

Methods of Skill Progression

How can you go from one skill level to the next? The 3-level will be awarded to you upon graduation from this course. The 5-level and 7-level will come after on-the-job training. This means you will have to study more advanced books, do good work on your job, and pass a written test.

TRAINING

The following are Air Force training resources:

a. Technical Schools

b. Career Development Courses (CDCs)

c. On-the-Job Training (OJT)

d. Extension Course Institute (ECI)

e. College Credit by Examination (CLEP) and (DANTES)

Now, let us discuss each of these resources and find out what each will do for you in your Air Force career.

Technical Schools

This is a technical school you are now attending. Throughout your Air Force career you will be given the opportunity to attend advanced technical schools. This type of training in your career will not normally result in an upgrade in your AFSC but will greatly aid you toward this end. All Air Force technical schools for the Environmental Support Specialities are taught here.

Career Development Course (CDC)

A CDC is aself-study course that you will be required to take. You will take it at the same time you do your on-the-job training. A separate CDC has been developed for the 5- and 7-level of your specialty. When you enter 5-level training, CDC 56631 is the course you will take. Later, you will take CDC 56671 as part of your 7-level training.

On-the-Job Training (OJT)

OJT is a planned training program designed to qualify you for upgrading in your AFSC. It consists of self-study and supervised instruction while you actually work in a duty assignment. The dual-channel OJT program consists of career development courses and job skill improvement. An AF Form 623, On-The-Job Training Record, will be maintained for you and will serve as a continuous record of all the career training you receive. This form is kept by your supervisor in the office of the shop where you will work.

Job Proficiency Training

A Specialty Training Standard (STS) will be used by your supervisor as a training document to identify the training you will receive at that duty assignment. This STS will now be placed in a training folder (AF Form 623) and will now be called a Job Proficiency Guide (JPG).

Extension Course Institute (ECI)

This is an agency of the Air University. It is better known as ECI with headquarters at Gunter AFS, Alabama. In addition to administering the career development courses, ECI also provides a program of voluntary off-duty military vocational training through correspondence study. These courses are referred to as extension courses.

The ECI program complements resident schools and other programs in meeting the USAF educational and training requirements. Correspondence study is a means whereby you may increase your knowledge and value to the Air Force. Completion of an extension course does not prevent you from taking a career development course or attending a resident course at a later date should the opportunity arise. In fact, completing an extension course will probably give you a background for the resident course. To apply for an extension course offered by ECI, all you have to do is fill out a Form 23 at the base education office stating which course you would like to take. There is a catalog at the base education office listing all the courses that you may take.

College Credit by Examination

The College-Level Examination Program (CLEP) General Exams battery includes five tests: English, Social Science, Natural Science, Humanities, and Mathematics. Scores from the tests may be evaluated by individual schools for as much as 30 semester hours of college credit. The CLEP Subject Exams measure proficiency in specific courses and result in college/university credit for successful examinees. Like the CLEP, the DANTES Subject Standardized Tests examine knowledge in specific course areas and result in college/university credit.

Credit by examination can be a tremendous accelerator for people seeking college degree completion.

Basic Skills Development

The Air Force's educational objective for enlisted personnel is for all enlisted members to be high school graduates. Your base education office provides free basic skills development classes (Reading, English and Math) during duty hours. In addition to helping prepare people for a high school diploma, these classes are also available to help people who are on OJT to strengthen their basic skills.

EXERCISE I-2-2b

Part 1

INSTRUCTION

Use SW J3ABR56631 000-I-2 to complete the following exercise.

1. Using your notes from today's discussion, complete the following statements.

   a. Your assigned AFSC is ________________________________.

   b. Your AFSC at completion of this school will be ____________________.

2. Identify the parts of the following AFSC number.

   ____56____ ____6____ ____3____ ____1____

3. Study the Career Field Chart (see SW J3ABR56631 000-I-2) and in the spaces below enter the AF Specialty Title and AFSC at each skill level in your career field.

Skill Level	Air Force Specialty Title	AFSC
1		
3		
5		
7		
9		

4. Career knowledge training is administered under one of two methods.

   a. ________________________________

   b. ________________________________

5. Job proficiency training is administered by supervisor's annotation of current ____________________, in order to develop the ____________________

   ____

6. Study the Rank-Skill Level Chart in SW J3ABR56631 000-I-2 and complete the following statements.

   a. From your present skill level of 1, you can attain the 3-level by

   ____

   ____

   b. Ask a 3-level you can become an A1C. To attain the 5-level you must ________

   ____

   ____

c. You can be promoted as high as ____________ with a 5-skill level. To advance from the 5- to 7-level, you must ______________________________

____

____.

d. To advance to the 9-level, you must ______________________________

____.

7. Complete the following statements.

a. The number of the Air Force Regulation that contains an airman's specialty description is ______________________________.

b. The AFSC of an airman before he is assigned to a career field is

____

c. Airmen being awarded AFSC 56691 may have formerly held AFSCs

____.

d. The Sanitation Superintendent carries the minimum grade of

____.

PART 2

INSTRUCTION

Use SW J3ABR56631 000-I-2 to complete the matching exercise listed below.

Match the followng AFSCs in Column A with the appropriate Grade/Rank in Column B. Each Grade/Rank may be used more than once.

COLUMN A	COLUMN B
1. 99000 ____________	a. CMSgt
2. 56611 ____________	b. SMSgt
3. 56631 ____________	c. MSgt
4. 56651 ____________	d. TSgt
5. 56671 ____________	e. SSgt
6. 56691 ____________	f. Sgt/SRA
	g. A1C
	h. Amn
	i. AB

PART 3

INSTRUCTIONS

Use SW J3ABR56631 000-I-2 to compelte the matching exercise below.

Match the AFSCs in Column A with the job titles in Column B.

COLUMN A

1. 99000 ______________________
2. 56611 ______________________
3. 56630 ______________________
4. 56631 ______________________
5. 56650 ______________________
6. 56651 ______________________
7. 56670 ______________________
8. 56671 ______________________
9. 56691 ______________________

COLUMN B

a. Apprentice Pest Management Technician
b. Sanitation Superintendent
c. Environmental Support Technician
d. Basic Airman
e. Pest Management Technician
f. Evironmental Support Specialist
g. Pest Management Specialist
h. Apprentice Environmental Support Specialist
i. Sanitation Helper

PART 4

INSTRUCTIONS

Use SW J3ABR56631 000-I-2.

List the four methods of career training progression and describe each as they apply to career progression.

METHOD	DESCRIPTION
______________________	______________________ ______________________
______________________	______________________ ______________________
______________________	______________________ ______________________
______________________	______________________ ______________________

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

Career field progression is a means of advancing in skill as well as rank. In your career field of Sanitation, you have an Air Force Specialty Code of 56611. When you graduate from this course, you will be awarded your 3-skill level.

Training programs in the Air Force are designed to fit all people regardless of what they do or where they are. You will be expected to enroll in one of them shortly after reaching your next assignment.

REFERENCES

1. AFR 35-1, Military Personnel Classificaiton Policy Manual

2. AFR 39-1, Airman Classificaiton Manual, Vol II

3. AFR 50-23, On-the-Job Training

3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

SW J3ABR56631 000-I-3

CIVIL ENGINEERING MANAGEMENT

OBJECTIVES

Given four statements, select the one that best identifies the BCE mission.

Given an incomplete BCE organizational structure chart, complete the chart by writing the names of the missing functional areas in the appropriate spaces. Three of the five must be correct.

Using a representative list of functions, responsibilities and a list of CE units, match the functions and responsibilities to the CE unit to which they apply. Six of nine must be correct.

Define property accountability and responsibility.

INTRODUCTION

When you leave here, you will be assigned to the Civil Engineers. Although much of your work will be maintaining mechanical equipment, you will have other jobs.

Paperwork is a necessary part of any job. Nobody really enjoys paperwork, but your job will be more rewarding if you know the correct procedures to accomplish it.

Information on resources and work force management will be covered under the following topics.

- BCE MISSIONS
- ORGANIZATIONAL STRUCTURE CHART
- FUNCTIONS AND RESPONSIBILITIES OF UNITS
- PROPERTY ACCOUNTABILITY

INFORMATION

BCE MISSIONS

The primary mission of Civil Engineering activities is to provide the necessary assets and skilled personnel to prepare and sustain global installations as stationary platforms for the projection of aerospace power in peace and war. The dual mission of war readiness and asset sustenance will be accomplished with an integrated military and civilian work force capable of rapid transition between missions. Specifically, Base Civil Engineering activities are organized to:

a. Maintain in the most economical manner all active property (or structures furnished in lieu of real property) to a standard that prevents deterioration beyond that which results from normal wear and tear, and inactive facilities to a standard commensurate with reactivation requirements.

b. Conserve natural resources through efficient land and forestry management and environmental pollution control and abatement.

c. Provide fire prevention and protection engineering services to prevent loss of life and property at all installations.

d. Furnish refuse collection and disposal, custodial, and insect and rodent control (entomology) services efficiently and economically.

e. Furnish military services required to accomplish assigned missions efficiently and economically.

f. Formulate and maintain a maintenance program that will accurately reflect the backlog of essential maintenance and repair.

g. Use contract services effectively to support or satisfy installation missions and requirements.

h. Accomplish alteratin and minor new construction necessary to provide essential facilities needed in support of mission changes (or other circumstances) which preclude programming under normal construction budget procedures.

i. Provide management and professional engineering services to ensure the most effective and economical operatin of all activities.

j. Support civil and air base disasters and emergenices, using the personnel and material resources of Civil Engineering as necessary to save lives, mitigate human suffering, and to minimize damage (see AFM 355-1).

k. Provide forces to recover air bases damaged by natural disasters or enemy attack, if damage or disaster is beyond local capability. Prime BEEF assistance will be requested of the major command (see AFR 93-2, AFR 93-3, and AFM 93-6).

EXERCISE I-3-3a

INSTRUCTION

Use SG J3ABR56631 000-I-3.

List four of the Civil Engineering activities.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. ______________________________

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

ORGANIZATIONAL STRUCTURE CHART

The structural alignment required for the Base Civil Engineer organization is prescribed by Air Force Manual 26-2. The Base Civil Engineer (BCE) is responsible for everything that goes on in his or her organization, however, one person cannot supervise everything. The BCE has executive managers, called branch chiefs, who help manage the organization.

BRANCH. There are seven branches in most Civil Engineering (CE) organizations. See figure 3-1. They are: Financial Management, Industrial Engineering, Family Housing Management, Squadron Section and Administraiton, Operations, Engineering and Environmental Planning, and Fire Protection. Each of these branches has a branch chief. Most branches are so large that the branch chief needs help managing what is going on. Therefore, most of the branches are broken down into sections.

SECTION. Each section is managed by a superintendent. Looking at figure 3-1 again, you will see that the Family Housing Management branch has three sections. They are Housing, Housing Referral, and the Programming and Studies section. Operations is the largest branch in CE. This branch has eight sections. These sections are: Resources and Requirements, Pavements and Grounds, Structures, Mechanical, Electrical, Electrical Power Production, Sanitations and Systems Management. Most superintendents would be over-worked if they tried to issue every order and assign every job to the workers in their sections. Again, looking at figure 3-1, you can see that most sections are broken down into units.

UNITS. Units, sometimes called shops, are controlled by supervisors. In the past these managers were called foremen, so don't be too suprised if the old timers still call the supervisor by that term. The sanitation section superintendent can have as many as four unit supervisors working for him or her. As an environmental support specialist you will work in the water or wastewater unit.

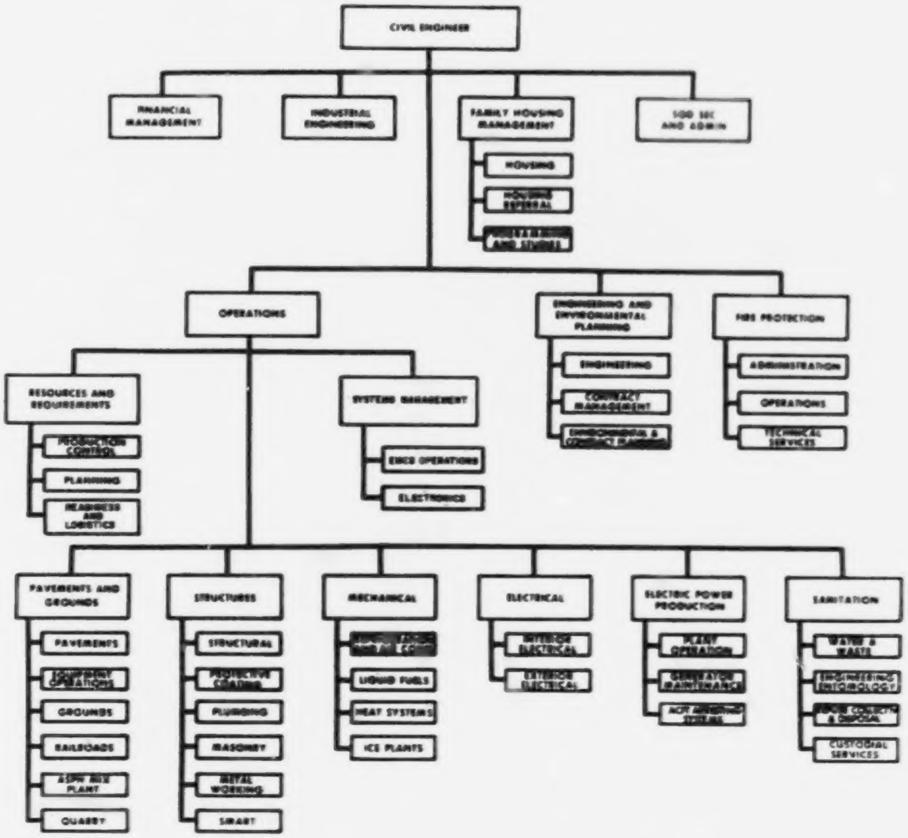

CIVIL ENGINEER
FINANCIAL MANAGEMENT
INDUSTRIAL ENGINEERING
FAMILY HOUSING MANAGEMENT
HOUSING
HOUSING REFERRAL
AND STUDIES
SQD SEC AND ADMIN
OPERATIONS
ENGINEERING AND ENVIRONMENTAL PLANNING
ENGINEERING
CONTRACT MANAGEMENT
ENVIRONMENTAL & CONTRACT PLANNING
FIRE PROTECTION
ADMINISTRATION
OPERATIONS
TECHNICAL SERVICES
RESOURCES AND REQUIREMENTS
PRODUCTION CONTROL
PLANNING
READINESS AND LOGISTICS
SYSTEMS MANAGEMENT
EMCS OPERATIONS
ELECTRONICS
PAVEMENTS AND GROUNDS
PAVEMENTS
EQUIPMENT OPERATIONS
GROUNDS
RAILROADS
ASPH MIX PLANT
QUARRY
STRUCTURES
STRUCTURAL
PROTECTIVE COATING
PLUMBING
MASONRY
METAL WORKING
SMART
MECHANICAL
LIQUID FUELS
HEAT SYSTEMS
ICE PLANTS
ELECTRICAL
INTERIOR ELECTRICAL
EXTERIOR ELECTRICAL
ELECTRIC POWER PRODUCTION
PLANT OPERATION
GENERATOR MAINTENANCE
ACFT ARRESTING SYSTEMS
SANITATION
WATER & WASTE
ENGINEERING ENTOMOLOGY
REFUSE COLLECTION & DISPOSAL
CUSTODIAL SERVICES
CA-46C

Figure 3-1. Base Civil Engineer Organizational Chart

EXERCISE I-3-3b

INSTRUCTION

Use SW J3ABR56631 000-I-3.

Fill in the blank spaces on the Base Civil Engineering Organizational Chart, figure 3-2, then give the major function of each shop in the space below.

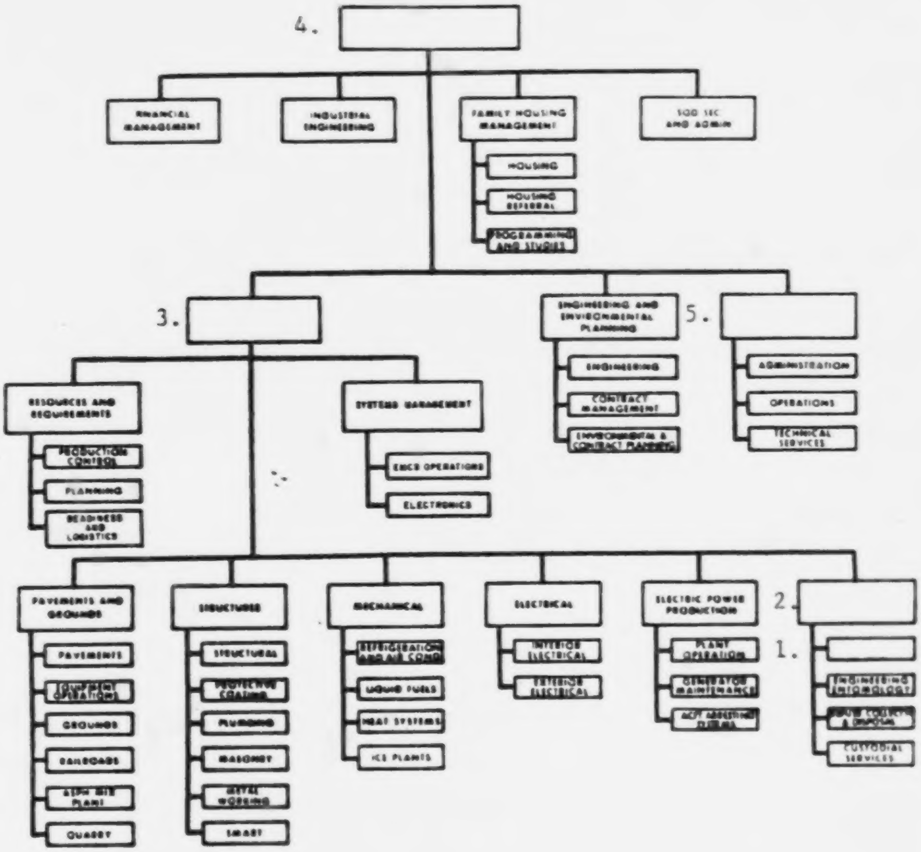
1.

2.

3

4.

5.



4.
FINANCIAL MANAGEMENT
INDUSTRIAL ENGINEERING
FAMILY HOUSING MANAGEMENT
SQD SEC AND ADMIN
HOUSING
HOUSING REFERRAL
PROGRAMMING AND STUDIES
3.
ENGINEERING AND ENVIRONMENTAL PLANNING
5.
RESOURCES AND REQUIREMENTS
SYSTEMS MANAGEMENT
ENGINEERING
CONTRACT MANAGEMENT
ENVIRONMENTAL & CONTRACT PLANNING
ADMINISTRATION
OPERATIONS
TECHNICAL SERVICES
PRODUCTION CONTROL
PLANNING
READINESS AND LOGISTICS
EMCS OPERATIONS
ELECTRONICS
PAVEMENTS AND GROUNDS
STRUCTURES
MECHANICAL
ELECTRICAL
ELECTRIC POWER PRODUCTION
2.
PAVEMENTS
EQUIPMENT OPERATIONS
GROUNDS
RAILROADS
ASPH MIX PLANT
QUARRY
STRUCTURAL
PROTECTIVE COATING
PLUMBING
MASONRY
METAL WORKING
SMART
REFRIGERATION AND AIR COND
LIQUID FUELS
HEAT SYSTEMS
ICE PLANTS
INTERIOR ELECTRICAL
EXTERIOR ELECTRICAL
PLANT OPERATION
GENERATOR MAINTENANCE
ACFT ARRESTING SYSTEMS
1.
ENGINEERING ENTOMOLOGY
REFUSE COLLECTION & DISPOSAL
CUSTODIAL SERVICES

Figure 3-2. Base Civil Engineering Organizational Chart

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

FUNCTIONS AND RESPONSIBILITIES OF UNIT

Functions of Civil Engineering

The Base Civil Engineer (BCE) is responsible for nine specific functions. A function is a special duty that must be performed by an organization. The nine functional responsibilities of the BCE are explained next.

MANAGEMENT OF AIR FORCE REAL ESTATE. There are people within CE who keep records on every piece of real estate that belongs to that base.

PLANNING AND PROGRAMMING. Someone needs to plan all work. This means from small jobs to large construction programs.

ENGINEERING AND CONSTRUCTION. CE has engineers who manage and supervise construction and related programs. They also inspect and accept completed real property constructed for the Air Force.

UTILITY SERVICE. Provides basic utility service in the most economic manner. As an environmental support specialist you will be providing the water and/or wastewater utilities at the base. Other utilities that CE is responsible for are electricity, gas, heating, cooling or air conditioning and sometimes ice manufacturing.

MAINTENANCE AND REPAIR OF STRUCTURES AND EQUIPMENT. When real property is maintained and kept in good repair it can last for many years. Your job will also include the maintenance and repair of plant equipment and real property.

TRAINING AIDS. Some Air Force bases have CE personnel who build and repair trainers. The trainers that you will be using here at school are built and repaired by CE people.

SERVICES. Cleaning buildings, removing snow from the runway and roads around the base and the refuse collection around base are some of the services that CE provides.

FIRE PROTECTION. What community could get along without fire proteciton. CE provides the fire protection on an Air Force base.

FAMILY HOUSING MANAGEMENT. The Air Force knows that if the member's family is well taken care of, he or she will be a good worker. CE is responsible for seeing that there are clean homes for the personnel at that base.

Nine functions didn't sound like much at first, did it? Through the proper use of his or her resources, the BCE can get this job done.

Use of Resources

The BCE has two ways of getting the work done. They are, contract and in-service.

CONTRACT. Most BCEs use contractors to do the custodial services of office spaces and to do large construction projects.

IN-SERVICE. Military and civilian personnel are assigned to the CE organization.

Responsibilities

Were you surprised to find out that there will be civilians assigned to your units with you? Let's see if there is any difference between their responsibilities.

CIVILIAN PERSONNEL. Civilian personnel are used chiefly to perform maintenance and repair of real property facilities, structures and equipment and to operate the utility systems. They may also be used to perform minor construction.

MILITARY PERSONNEL. Military personnel, in the BCE organization, are used chiefly for direct combat support roles in support of the Air Force mission, under the Prime Base Engineer Emergency Force (BEEF) concept. In addition, you will perform those duties cited for civilian personnel. Your duties will be diversififed enough to maintain the competence necessary for you to carry out your direct combat support roles.

UNIT. Your responsibilities in the water treatment area will be to operate, maintain and repair water plants, water distribution systems, and water pollution control plants and systems. You may also operate and maintain a demineralized water treatment plant, in order to treat water for aircraft use. If you work in a wastewater treatment plant you will find yourself operating, maintaining and repairing wastewater plants and equipment. You will find yourself concerned with meeting federal regulations that prevent environmental pollution. As you can see, the environmental support unit, of the sanitation section, is a very important place to be working.

EXERCISE I-3-3c

INSTRUCTION

Use SW J3ABR56631 000-I-3 to complete the following questions.

1. In your own words, or those of this text, define the word "functions".

2. Name the two functions within the BCE responsibilities, that you will most likely find yourself involved with.

3. Name the two types of in-service personnel resources that will be found within a CE organizatin.

4. What is the chief role of the military personnel assigned to a Civil Engineering organization?

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

PROPERTY ACCOUNTABILITY

Management of public property is the process of providing for the proper allocation, control, care, use, and safeguarding of public property under control of the Air Force. This process applies to each individual, whether or not property is receipted for or issued to that individual for care or custody. Property management responsibilities require limiting the use of these resources.

Responsibility for managing public property is an obligation shared by all Air Force personnel, military and civilian, regardless of duty assignment and level of supervision or command.

Property management responsibility includes pecuniary liability for the loss, damage, or destruction of property resulting from unauthorized issue, gross negligence, willful misconduct, or deliberate unauthorized use.

Great quantities of equipment and material are needed to allow a large organizaiton such as the Air Force to function properly.

Equipment and material needed in the Air Force are costly and someone must be directly responsible for its safekeeping. Custodians are assigned for this reason.

Custodial Accontability

Each functional area in the Air Force has its own custodian who is responsible for accountable equipment and material assigned to that area. All items of accountable equipment and material are recorded on a machine run listing and made a matter of record for the custodian. Periodic inventories are performed to insure that accountable equipment and material are still on hand and being maintained.

Personal Responsibility

Indiviudals are directly responsible for equipment such as toolboxes that are assigned to them.

Indirectly you are responsible for the safekeeping of all Air Force property even though you are not the custodian in charge.

TEMPORARY ISSUE RECEIPTS (AF Form 1297)

The Temporary Issue Receipt, sometimes called an issue turn-in slip, is used by every section in the Air Force. Equipment may be loaned to other sections to help them to do some of their work. When you loan out this equipment, you must have some type of receipt to show who loaned the equipment and who received it. The form used in this case will be the Temporary Issue Receipt, AF Form 1297. The original of this form is kept by the person responsible for safekeeping of the equipment and the duplicate is given to the person that signs for the borrowed equipment. Following is an example of a completed 1297.

EXERCISE I-3-3d

PART 1

INSTRUCTION

Use SW J3ABR56631 000-3, to answer the questions below.

1. When loaning a piece of equipment, which form would you use to transfer responsibility for the equipment?

2. Who is directly responsible for equipment assigned to a functional area?

3. Who is indirectly responsible for AF equipment?

PART 2

INSTRUCTION

Use your notes to complete this exercise.

Temporary Issue Receipts (AF Form 1297)

The following list of items below are entries normally used in filling out a temporary issue receipt. Fill out the temporary issue receipt below and place the entries in the correct block.

1. John Cochran
2. ea
3. 6810-463-2789
4. 10 July 80
5. MSgt Gibeau
6. $6.95
7. 5 Jul 80
8. 10
9. Valve, Gate, 1/2"
10. 4680
11. Maj Henseley
12. John Cochran AMN, CES

TYPED OR PRINTED NAME, GRADE AND ORGANIZATION	TO: *(Responsible Officer)*	ORG ACCT NO	DATE ITEM(S) TO BE RETURNED

STOCK NO.	DESCRIPTION	UNIT	QUANTITY ISSUED	COST

I ACKNOWLEDGE RECEIPT AND RESPONSIBILITY FOR ITEM(S) SHOWN IN "QUANTITY ISSUED" COLUMN, WHICH WILL BE RETURNED ON DATE SPECIFIED ABOVE.

DATE	SIGNATURE	DUTY PHONE	ISSUED BY

AF FORM SEP 70 1297 PREVIOUS EDITIONS WILL BE USED **TEMPORARY ISSUE RECEIPT** ☆GPO: 1971 – 427/611

Figure 3-3

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

The organizational chart breaks down the Civil Engineer chain of command, which includes the Sanitation Section. The Sanitation Section is responsible to the Operations Branch.

If you loan equipment out, use the Temporary Issue Receipt (AF Form 1297) to transfer responsibility and safekeeping of the equipment to the borrowing person.

A custodian is responsible for accountable equipment that is used in his or her area. Periodic inventories are made to insure that the equipment is still on hand and in good condition.

REFERENCES

1. AFR 85-1, Resources and Work Force Management
2. AFR 85-10, Operation and Maintenance of Real Property
3. GSA Stock Catalog

3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

SW J3ABR56631 000-I-4

SECURITY (OPSEC)

OBJECTIVE

Given information pertaining to the operational activities related to AFSC 566X1, select three activities which indicate OPSEC vulnerabilities.

INFORMATION

Operations security (OPSEC) in squadron contingency operations is one area of vulnerability. The BCE has an important role in contingency operations for the base. We have certain responsibilities related to alerts during wartime operations. Our Prime BEEF teams are another area of vulnerability. During your stay in the Air Force and in CE, you may possibly be assigned as a member of a Prime BEEF contingency team and as a member you will have access to such information as strength figures, alert status, destination of a team on alert status, etc. This type of information should not be talked about with individuals not having authorization, and a need to know. An enemy agent obtaining bits and pieces of this information could find out the extent of the whole operation and take action which could result in the failure of the mission, and possible loss of many lives.

There are also OPSEC vulnerabilities related to your own job. In the environmental field we do things which gain us access to information which would be vulnerable to OPSEC. We at times must enter areas which have classified information. For example, when we must work in an alert facility, or hangars, base operations and even in the command post. During this time we may learn such things as status of aircraft, duty lists of the crews, and more information. While we are producing demineralized water, we may see planes being camouflaged, materials being loaded on planes or being stored to support an operation. This kind of information in the wrong hands could be very deadly and you should not talk about it.

In the environmental field we have access to other information which would be vulnerable to OPSEC. We have such information as the total number of gallons and type of water we treat. This in itself could show excess aircraft activity and base population. We would also know if any portable water purification units were being made ready for use for a Prime BEEF operation. This kind of information is also vulnerable to OPSEC.

Emphasis on OPSEC must continue during peacetime. This emphasis is maintained by developing a strong OPSEC training program, by using sound OPSEC principles, by stressing enemy intelligence colleciton capabilities, and by conducting OPSEC surveys of various peacetime operations such as exercises, unit movements, systems development, and logistics support. Additionally, continuous command attentions is required to assure that plans, procedures, and training, encompass imaginative and practical OPSEC considerations, and that personnel were motivated to use effective OPSEC principles.

OPSEC, COMSEC, information security, and physical security are interrelated and mutually supporting programs. However, OPSEC has broader application in that it seeks to protect unclassified and otherwise highly visible aspects of an operation as well as classified aspects. It makes little sense to protect an operation by classifying some parts of it, or to expend COMSEC resources protecting information about it, when unclassified conversations, sterotyped procedures, and other readily available data could provide an enemy with meaningful intelligence indicators. An effective OPSEC program will eliminate or control many of these indicators.

OPSEC must be a matter of continuing concern throughout the life of an operation.

Specific operations orders, programs, standard operating procedures, and supporting plans and procedures must be:

* Developed with the awareness that the enemy can identify and exploit vulnerable activities.

* Designed to provide the highest possible degree of security without degrading the effectiveness or safety of an operation.

* Designed to degrade or deny to the enemy sources of information vulnerable to exploitation. In order to degrade the validity of the sources of information, the use of counterintelligence activities and deception should be considered, where appropriate.

Security safeguards must be continued through the execution phase of an operation. This effort includes appropriate supervision to ensure that sound OPSEC practices are followed during execution as well as during planning. OPSEC survey techniques and assistance from other agencies may be helpful in this supervision.

In the same manner, the critique and reporting phases of an operation can yield valuable intelligence to an enemy if OPSEC principles are not continued.

COMMON OPSEC VULNERABILITIES

Operaitonal Indicators

Stereotyped sequences of events comprising various phases of the operation.

Coordination with other agencies that do not have proper safeguards for sensitive information.

Submission of unclassified reports at specific intervals to specific units of levels of command.

Sterotyped patterns of flight activity at a particular location.

Procedural Indicators

Public information releases.

Posting of operational plan information in insecure areas.

Posting of rosters, transportation scheules, and dining hall schedules in insecure areas.

Distinctive emblems or paint on vehicles, buildings or aircraft.

Markings on supplies which could reveal the location or starting date of the operations, such as, nicknames, delivery deadlines, etc.

Logistics build-up or positioning of support materials and facilities.

Special briefings, meetings or religious services.

The use of nicknames; particularly hazardous since they provide an esasily recognizable flag for identification of an operation.

Exercising or testing portions of a plan.

Communications Indicators

Plain language communications associated with a planned operation and conducted during the planning preparatory and execution phases.

Use of unchanging or infrequently chaning call sings and/or radio frequencies.

Stereotyped message characteristics which are indicative of particualr types of military activity.

A significant increase or decrease in message traffic volume.

Activities of new communications facilities in support of an operations plan.

SUMMARY

Operations Security is a program which surveys and applies controls to COMSEC, information, and physical security to deny valuable information to the enemy.

The need for overall security is not limited to major combat operations, but is also important for any operation, including peacetime maneuvers. In the case of combat operations, prior knowledge by the enemy can give him time to take defensive action which will cause the operation to be ineffective or fail completely. Peacetime operations which are known to a potential enemy can give him/her an advantage militarily and diplomatically.

We have shown you some of the job related situations which are vulnerable to OPSEC. You will be obtaining bits of unclassified information which if talked about with the wrong individuals could given an enemy agent insight into an operation which is classified.

QUESTIONS

1. What squadron contingency operations are vulnerable to OPSEC?

2. What type of duties do we perform in the environmental field which would give us access to information which could be vulnerable to OPSEC?

3. What type of information do we have access to that would be vulnerable to OPSEC?

EXERCISE I-4-4a

From the following list of operational activities related to AFSC 566X1, place a check mark next to those activities taht indicate OPSEC vulnerability.

____ 1. You are a member of a Prime BEEF team and you are on alert, you discuss this with your next door neighbor.

____ 2. You discuss, with your supervisor, a problem that you are having with the unit that supplies water for the aircraft.

____ 3. You tell a friend of yours that you are going to be working on a new type of portable purification unit the base is receiving for the Prime BEEF exercise.

____ 4. During your trip to take a well reading in the flight line area you see aircraft being camouflaged. You then discuss this information with a buddy you know at a local drinking establishment.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

TECHNICAL PUBLICATIONS

OBJECTIVES

Use numerical indexes and requirement tables, locate the title of a manual, a regulation, and a technical order when the numbers are known, with no more than three instructor assists.

Using a manual, a regulation, a technical order and a commercial publication, find the answer to given problems with no more than three instructor assists.

Given information pertaining to a technical order deficiency, select the action that should be taken to correct the deficiency. Three of the four must be correct.

Using the parts of a GSA supply catalog and an incomplete list of stock numbers and nomenclatures, locate and list the missing information with no more than two instructor assists.

INTRODUCTION

Civil Engineering also has the function of maintaining, preparing and filing information on current plans which pertain to various structures and equipment on base. Structures may include a facility, building or a piece of equipment attached to that building. The structure can be either permanently or temporarily installed or constructed. These structures are called Real Property Installed Equipment (RPIE). These various structures can include water pump stations, lift stations, water plants, wastewater plants, electrical control panels, pavements, curbing, and support equipment. Government furnished domestic appliances that are part of public quarters, dormitories or base support facilities are also considered real property. Specific standards and records are maintained on real property, materials and equipment to meet the design requirements for construction, capacity, fire safety, expenditure of resources, current and planned usage, replacement costs, and several other type criteria to make the most economical and practical use per cost capita. Real property facilities and equipment will be evaluated according to requirements included in technical publications or at least once each year or more often if extensive usage or environment makes it necessary in order to complete work requirements.

Files and current plans on Real Property Installed Equipment must be maintained and updated consistantly. The maintenance information required may include:

1. Active installations
    a. Airfield pavements
    b. Permanent and semi-permanent buildings
    c. Temporary buildings and structures
2. Inactive installations
    a. Facilities programmed for future use
    b. Fire and guard protection
    c. Utility systems
    d. Facilities and equipment awaiting disposition

A master publications library is authorized at base level by AFR 5-31. The library will include many types of publications issued by the base or higher authority, Air Force Regulations (AFRs), Air Force Manuals (AFMs), and Air Force Pamphlets (AFPs) are issued by higher authority and apply to the base.

The Air Force Technical Order (TO) system is the only official medium for disseminating technical information. Instructions and safety procedures for maintenance of equipment is covered by the TO system.

The General Services Administration (GSA) catalog gives you information you need for supply items, stock, and nonstock in the GSA supply system.

INFORMATION

First is the purpose of technical publications, the types of technical publications, identification of indexes and how to use the indexes.

EXERCISE I-5-5a

PART 1

INSTRUCTIONS

Use TOs 0-1-01, 0-2-1, 0-1-40, 00-5-1, 40W-4-9-1, 40W-4-9-14, and AFR 0-2 to complete the following questions with title or numbers.

	NUMBER	TITLE
1.	0-1-11-6	______________________
2.	0-1-10	______________________
3.	__________	Shop Machinery and Associated Equip
4.	__________	Standard and Special Tools Technical Orders
5.	AFR 91-26	______________________
6.	AFM 91-32	______________________

PART 2

INSTRUCTIONS

Use SG 53, 54, 55, 56, Publications to complete the following.

1. Identify what each of the following numbers stand for when it follows the last dash in a TO number:

a. -1 ______________________________

b. -2 ______________________________

c -3 ______________________________

d. -4 ______________________________

2. Identify each digit of the following TO number on the blank lines provided.

TO 40 W 4 -9 -1

3. List the numerical Technical Order index number. ______________

4. List the alphabetical Technical Order index number. ______________

5. List the TO index number for the 40 category TOs. ______________

PART 3

INSTRUCTIONS

Match the following publication in Column A with the response in Column B. Each response may be used once, more than once, or not at all.

COLUMN A

_____ 1. AFR 0-2

_____ 2. TO 0-1-01

_____ 3. TO 0-2-1

_____ 4. TO 0-1-40

_____ 5. TO 00-5-1

_____ 6. TOs

_____ 7. AFR 91-26

_____ 8. TO 00-5-2

_____ 9. AFM 91-32

COLUMN B

a. Alphabetical listing of equipment and technical publications number groups

b. Numerical and subjective index of standard publications and recurring periodicals

c. Commercial air conditioning, heating, plumbing, refrigerating, ventilating and water treatment equipment TO

d. Numerical Index, Master

e. Maintenance and operation of water supply, treatment, and distribution systems

f. Pertains to accident prevention

g. Index of water plants

h. Operation and maintenance of domestic and industrial wastewater systems

i. Airman's Classification Manual

j. Air Force Technical Order System

k. Tell how to obtain and distribute TOs

l. Detailed information and illustrated parts breakdown

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

Using a manual, a regulation, a technical order, and a commercial publication, correctly locate information about equipment operation, maintenance, overhaul and parts breakdown. Also there is the guide and rules that we must follow day-by-day.

EXERCISE I-5-5b

PART 1

INSTRUCTIONS

Using AFR 91-26, find and circle the errors in the statements listed below.

1. Before operation service of gasoline engines check fuel pipe to see if frozen. If fuel pipe is frozen do thaw with open flame.
2. When repacking gate valves (not buried), check and service all parts of valve completely. Remove stem polish lightly with fine file to put stem in good condition.

PART 2

INSTRUCTIONS

Using AFM 91-32, find and circle the errors in the statements listed below.

1. Heat the primary digester to about 105°F to 110°F.
2. Disinfection of wastewater is the killing of disease causing or pathogenic micro-organisms in water. The pathogens most often found in industrial wastewater can cause dysentery, cholera, typhoid and paratyphoid.

PART 3

INSTRUCTIONS

Using AFR 39-1, find and circle the errors in the statements listed below.

1. The duties and responsibilities of the plant operator consist of eight duties.
2. In the specialty qualification the completion of college with courses in chemistry and physics is desirable.

PART 4

INSTRUCTIONS

Use the TO indicated in the statements listed below to complete the phrase.

1. Using TO 0-1-40, find the TO for Operating Purification Unit. Models 600-2500, 600 gal per hour trailer mounted.

   ____

2. Using the TO found in step 4, locate the electric control box and components and complete the following statement.

   The low water level warning light works in conjunction with the ____________________

   when the water level is ____________________ in the well.

3. Use TO 40W4-9-14, Organization Maintenance Repair Parts and Special Tool List, locate and recod the figure number ____________________, Item number ______________ and stock number ______________________ of the warning buzzer on the electrical control box.

PART 5

INSTRUCTIONS

Using TO 40W4-13-1, find and circle the errors in the statements listed below.

1. Cartridge filter tube elements should be changed when cartridge filter gauge differential pressure rises above 40 psid.

2. In choosing the site, your raw water hoses can reach about 50 feet.

PART 6

INSTRUCTIONS

Using 94 series solution metering pump instruction book, find and circle the errors in the statements below.

1. Cleaning pumping parts, a white deposit may form on all parts in contact with the solution. This is most easily removed by soaking the parts in sulfuric acid which can be obtained locally.

2. When reassembling pumping parts, screw the diaphragm onto the cam unit. Turn the knob to 0 on dial and position the pump mechanism to fully retract the diaphragm.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

The correction of minor inaccuracies of a non-technical nature will not be recommended on improvement reports unless such inaccuracies change the meaning of instructive information and procedures.

EXERCISE I-5-5c

INSTRUCTIONS

Use TO 00-5-1 to find the correct responses to statements below.

1 Who is responsible for reporting mistakes or deficiencies in technical orders?

____

2. List the form number and title of the AFTO form used to report TO deficiencies.

____

3. Select the action which should be taken when these deficiencies are found.

a. Correct the error using black ink

b. Fill out AFTO Form 22 and report it to your supervisor

c. Report it to your supervisor and make the correction in black ink

d. Report it to your supervisor.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

Air Force Supply Manuals and Catalogs are very valuable in your job. In order for these manuals and catalogs to aid you, you must know the purpose and breakdown of these manuals and catalogs.

Purpose of Supply Manuals and Catalogs

Air Force Supply Manuals and catalogs aid you when you need to find the information to order equipment and materials that you use.

GSA Federal Supply Catalog

The General Services Administration (GSA) Catalog gives you information you need for all supply items, stock and nonstock in the GSA Supply System.

EXERCISE I-5-5d

PART 1

INSTRUCTIONS

Using the GSA Stock Catalog, Part I, locate the stock numbers, prices, and page numbers for the following listed items.

	NAME OF ITEM	STOCK NUMBER	PRICE	PAGE/ COLUMN
1.	Helmet, Construction, Workers			
2.	Envelope, Wallet 4 x 9 1/2"			
3.	Handle, Chisel and Gauge Lg 5 1/2"			

PART 2

INSTRUCTIONS

Using GSA Federal Stock Catalog Part I and II, locate the name, unit of issue, page and column number of the following stock numbers.

	STOCK NUMBER	NAME OF ITEM	UNIT OF ISSUE	PRICE	PAGE/ COLUMN
1.	5210-00-243-3349				
2.	6640-00-051-9490				
3.	3750-00-255-7734				

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

Air Force Regulations announce policies, assign responsibilities, and direct actions.

Air Force Manuals contain permanent and detailed instructions, procedures, and techniques that enable personnel to perform their duties.

Air Force Pamphlets usually contain informative material, rather than directive material. However, some are directive, as in the case of AFP 85-1.

Air Force Manuals, Pamphlets, and Regulations are indexed in AFR 0-2 along with Recurring Periodicals and Visual Aids.

A Publications Bulletin is issued bi-weekly to advise on the availability of publications and forms distributed by the AF Publications Distribution Center.

To be of maximum value to your organization and the Air Force, you should make a great effort to keep current on new publications and changes to publications pertaining to you and your organization. You should especially review new indexes frequently for the purpose of identifying new publications which will assist you in your work.

REFERENCES

SG AFS 54, 55, 56, Publications
AFR 0-1, Numerical Index of Standard and Recurring Air Force Publications
AFR 39-1, Airman Classification Regulation
AFR 91-26, Maintenance and Operation of Water Supply, Treatment and Distribution Systems
AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems
TO 0-1-01, Numerical Index, Alphabetical Index Cross-Reference Table
TO 0-1-02, General Technical Order
TO 00-5-1, Technical Order System
TO 00-5-2, Technical Order Distribution System
TO 40W4-9-1, Operator and Organizational Maintenance Manual WPU Trailer Mounted 600 GPH
TO 40W4-9-14, Organizational Maintenance Repair Parts and Special Tool Lists, Water Purification Unit, Trailer Mounted 600 GPH
TO 40W4-13-1, Water Purification Unit Reverse Osmosis, 600 GPH, Trailer Mounted
AFTO Form 22, Technical Order System Publications Improvement Report and Reply

3770 Technical Training Group
(Civil Engineering Training)
Sheppard AFB, Texas

SW J3ABR56631 000-I-6

SAFETY PROGRAM AND ACCIDENT PREVENTION

OBJECTIVES

Identify two basic facts about the Air Force safety and accident prevention program.

Given a list of shop and plant safety hazards, write the method of eliminating each hazard in accordance with Air Force directives with no more than one instructor assist.

INTRODUCTION

As an Air Force specialist or technician, you should have two primary aims in life: one, to do a first-class job in your assigned duty; the other, to return to civilian life, either by discharge or retirement, in as good a physical condition as possible. A thorough knowledge of the hazards confronting you, the established safety rules to protect you, and your observance of these safety rules, may determine what condition you will be in when you return to civilian life. In fact, it could determine whether or not you live long enough to become a civilian again.

INFORMATION

This study guide/workbook is designed to help you prevent injury or death to yourself or to your fellow worker, and to prevent damage or destruction of Air Force equipment. This valuable information will be presented as follows.

- ACCIDENT PREVENTION PROGRAM
- SHOP AND PLANT SAFETY HAZARDS

EXERCISE I-6-6a

INSTRUCTIONS

Use study guide AFS 54, 55, and 56 to complete the following statements.

1. What is the general purpose of the Air Force Safety Program?

2. What are the three causes of accidents?

3. What are some ways of preventing poor housekeeping?

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

EXERCISE I-6-6b

INSTRUCTIONS

Using your notes, answer the statements below to eliminate the hazard.

1. A plant operator has fallen into a tank.

2. A plant operator has lost two fingers because of moving part at plant.

3. A plant operator became very sick after eating lunch in break area.

4. The lab operator has gotten serious acid burn.

5. The lab technician uses a lab beaker for a substitute cup and shortly thereafter becomes sick.

____

____

____

6. A plant worker is using a tool that starts a fire.

____

____

____

7. A plant operator finds his/her fellow worker laying face down in the chlorine room.

____

____

____

____

8. An unauthorized person was looking around the plant, while inside the plant the person lights up a cigarette and causes an explosion.

____

____

____

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

The Air Force maintains a ground safety program designed to prevent accidents. Don't forget that most accidents can be prevented. Your part in this ground safety program is to become familiar with the causes of accidents and to follow the rules and precautions to prevent them. Some of the conditions which breed accidents are poor housekeeping, horseplay, improper use of tools and equipment, nonobservance of warning signs, and lack of an adequate fire prevention program. Of course, there are many other causes, among these are cases of personnel working with unfamiliar equipment or material. Therefore, to prevent accidents, it is necessary to know as much as you possibly can about the equipment and materials you work with. As an Environmental Support Specialist you will be working with, or near, such items as mechanical equipment, electrical equipment, liquid and compressed gases, acids and possibly even radioactive materials. Take the time to learn as much as you can about these things. Air Force manuals, pamphlets, technical orders, and commercial texts are available for you to learn this material.

REFERENCES

AFR 127-12, Air Force Occupational Safety and Health Program
AFOSH STD 127-66, General Industrial Operations

3770 Technical Training Group
(Civil Engineering Training)
Sheppard AFB, Texas

SW J3ABR56631 000-I-7

CORROSION CONTROL

OBJECTIVES

Using information pertaining to corrosion, list the causes and types of corrosion. Five of eight must be correct.

Identify the three methods used to control the corrosion process.

INTRODUCTION

Corrosion is the process of metals changing back to their natural state. Corrosion is essentially the same in all metals. However, the rate of corrosion will vary with different types of metal, and more so in different environments. Therefore, corrosion can be defined as the deterioration of metals as a result of an unfavorable environment. This study guide will discuss the basic causes of corrosion, types of corrosion, and methods of preventing corrosion under the following main topics.

- THE CORROSION PROCESS
- TYPES OF CORROSION
- PREVENTION OF CORROSION

This study guide will not contain all the information you need to know about corrosion. Therefore, research of the reference material at the end of this study guide is highly recommended.

The Corrosion Process

We already know that corrosion of metal is deterioration which is the result of an unfavorable environment. We need to know what causes some of these unfavorable environments.

For many years there seems to have been little thought regarding the causes of corrosion, even though a few observations were made. Due to the results of these observations many in-depth studies have been made in the last few years. From these studies it has been found that the control of corrosion is a big factor in the operation of water and waste systems. Corrosion on utility systems can interfere with the accomplishment of the base mission since it will cause plants to be shut down for repair. It has been found by the National Association of Corrosion Engineers that corrosion will cause losses of more than 6 billion dollars per year. The Air Force share of this huge cost runs into several million dollars per year. This shows the need for an effective control program. Such a program cannot do away with all corrosion, but it can reduce it by a high percentage.

You must first know some of the facts about corrosion so that you can control it. Corrosion is the deterioration of metal in the process of returning to its natural state. It will change into a different substance. An example is the rust on iron. The iron goes through a change or chemical reaction. The change from iron to iron oxide (rust) is the process of iron changing back to its natural state. If you could collect enough iron oxide it could be refined into iron once more.

This deterioration of metal known as corrosion takes place in one of several forms which we will talk about in more detail later in this lesson. The most common types or forms of corrosion that you will see in the water and waste field will be either the Chemical or Electrochemical type. These two types or forms of corrosion are caused by the flow of electrical energy from one point to the other.

Where does this electrical energy come from? Most of you have some knowledge of electrical energy, but in most cases not enough for a good understanding of corrosion currents.

All metals have an electrical potential voltage. This is in the form of stored energy. It might be said that this energy is trying to find a place to go. When two metals are joined in the presence of an electrolyte (any liquid or moist substance that will conduct electricity) the one with the higher potential gives up electrical ions to the metal that has the lower potential.

This flow of electricity, together with the type of electrolyte involved, creates a favorable environment for the metal that has the highest potential to corrode. The order of potential of the different common metals is given in the E.M.F. (Electromotive Force Series) Chart shown in figure 7-1. The speed of corrosion is determined by the amount of separation of the metals in the E.M.F. series. This can be seen if you will read the potential in the right column of the series chart. Therefore, the greater the separation, the greater the chance for a corrosion cell to exist.

The E.M.F. series was developed through experiment and by measurement of the difference in electrical potential of these metals. The difference in electrical potential is caused by the atomic structure of the metal.

ELECTROMOTIVE FORCE SERIES CHART

Anodic End or Most Corrosive

METAL	ELECTRICAL POTENTIAL
MAGNESIUM	- 2.37
ALUMINUM	- 1.66
MANGANESE	- 1.18
ZINC	- 0.76
CARBON STEEL	- 0.71
CAST IRON	- 0.62
LEAD	- 0.13
HYDROGEN	0.00
TIN	+ 0.15
BRASS	+ 0.20
COPPER	+ 0.34
BRONZE	+ 0.47
MERCURY	+ 0.79
SILVER	+ 0.80
GOLD	+ 1.68

Cathodic End or Least Corrosive

Figure 7-1. Electromotive Force Series Chart

Figure 7-1 does not include all of the corrosive metals, and the metals listed will have different electrical potentials in different electrolytes.

The metal that has the highest potential is known as the anode. Current will flow from the anode to the cathode (the point with the lowest potential); this current flow will carry metallic ions with it and cause the metal to waste away. The process is known as galvanic corrosion. We discussed the source of electrical energy earlier in this lesson; the same basic principle that was discussed will apply to all electrochemical (galvanic) attack corrosion.

There are two rules to remember about galvanic corrosion currents. These rules will apply to all electrochemical corrosion cells.

1. Where the electrical current leaves the metal (anode) it corrodes.

2. Where the electrical current enters the metal (cathode) it is being protected.

These rules can be applied to all galvanic conditions. For a better understanding of a galvanic corrosion cell, let us use a dry cell battery as an example. The dry cell battery has a cathode (carbon rod), anode (zinc can), electrolyte (salmonic paste), and an electron path (the connection between the cathode and anode). This electron path is not completed until the battery is installed for operation. All dry cell batteries are built with these parts and all galvanic corrosion cells will have these same parts. See figure 7-2 for an example.

When the connection is made between the two terminals of the battery the ions start to flow, this is called current flow. This flow will continue until you break the connection or the anode is completely eaten up or displaced.

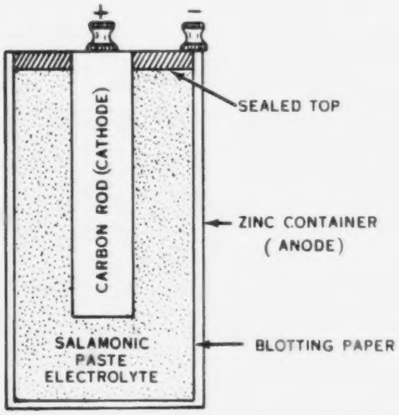


Figure 7-2. Dry Cell Battery

Electrochemical reaction means that a chemical change and an exchange of electrical energy take place at the same time. Thus, when corrosion occurs, there is a current flow from the corroding portion of metal into the electrolyte or conductor, such as water or soil.

The current flow from the metal takes particles of metal with it. The charged particles are called ions. As the metallic ions are dissolved in the electrolyte, they are exchanged for hydrogen ions, which flow to the cathode and tend to deposit a hydrogen film on the cathode. The metal particles carried from the parent metal are usually changed to oxides as they move into the electrolyte and are deposited as corrosion products, most often near or on the anode. In the case of steel, these oxides form rust.

There are several ways in which a galvanic cell may be formed. We have already discussed the dry cell battery type. Another type of corrosion cell is one with two metals and one electrolyte as shown in figure 7-3.

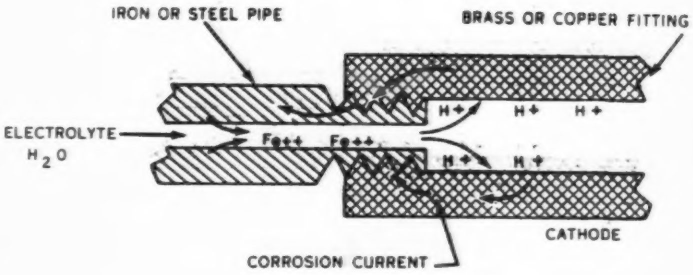

IRON OR STEEL PIPE
BRASS OR COPPER FITTING
ELECTROLYTE
H_2O
Fe++
Fe++
H+
H+
H+
H+
H+
CATHODE
CORROSION CURRENT

Figure 7-3. Corrosion Cell

In the above example the iron or steel that has the higher electrical potential gives up ions to the lower potential of the brass or copper, therefore creating a galvanic cell.

Another type of galvanic corrosion cell found in water and waste systems is one on metal with a dissimilar surface on the same structure. See figure 7-4 for an example.

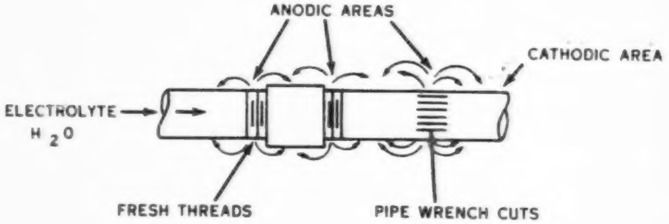

ANODIC AREAS
CATHODIC AREA
ELECTROLYTE
H_2O
FRESH THREADS
PIPE WRENCH CUTS

Figure 7-4. Galvanic Corrosion Cell

In figure 7-4 the new threads and pipewrench cuts become anodic to the remainder of the pipe, due to the dissimilarity of the two surfaces even though it is on the same metal. These bright spots rust (corrode) at a high rate, and cause the pipe to be weak at that point.

Chemical Attack

This is a type of corrosion that is found in water and waste plants and is caused by large amounts of chemicals used in these plants.

Chemical attack of metal is easy to find and is also easy to stop. Most metals will corrode when they come into contact with acids. If you place a drop of strong acid on a piece of iron, you can see it boil. After a short contact with the metal, you can see the pits or holes left in the metal by the chemical attack of the acid. Some metals will resist chemical attack by acid, but will corrode readily when exposed to alkalies. Almost all metals will have some reaction with either the acid or the alkali and some will be affected by both.

Most chemical attack of metal will take place in industrial waste or by chemical spillage. Both of these would cause an unfavorable environment because they increase the amount and rate at which corrosion will spread.

Chemical attack corrosion can be stopped most of the time by preventing chemical spills, venting chemical fumes away from equipment, or by using equipment built of materials that will not be harmed by chemical attack. Generally any measure that will eliminate the unfavorable conditions will slow down chemical attack corrosion.

Bacteriological Type of Corrosion

This is a type of corrosion which is caused by the electrolytic or galvanic cell action of biological organisms. By definition, bacterial corrosion is the deterioration of metals by corrosion processes which occur as a result of the activity of bacteria in water or soil. The organisms which cause bacterial corrosion are bacteria, slime, and fungi.

Microbiological Corrosion

Microbiological corrosion action in the soil is due to physical and chemical changes of the soil by bacteria. Some types of aerobic bacteria produce galvanic cells. These cells are produced by variations of oxygen in the soil (differential aeration) or the loss of the hydrogen film over the cathodic areas (depolarization).

Anaerobic bacteria are responsible for the reduction of sulfate salts into sulfide compounds. As already studied, sulfides, like hydrogen sulfide, vigorously attack most metals. Anaerobic bacteria is mostly found in water logged, sulfate bearing, blue clay type soils. The bacteria concentration as well as the corrosion rate varies considerably between the different seasons of the year. Cast iron and steel piping will rust due to sulfide production.

Prevention of Corrosion

Since we have discussed some of the causes and types of corrosion, now let's cover the most important aspects of corrosion. That is the control of corrosion.

In a given situation, corrosion may have one cause or many. Therefore, control measures must be planned to meet the specific condition.

Designing Against Corrosion

Two steps are used in the general design to stop corrosion: (1) Use features that cause less corrosion from the start; (2) Design plants that make it easier to fight corrosion in the plant. Good design will use the least corrosive materials for a given environment. Among light metals, aluminum, magnesium, and cadmium are best; heavy metals include cast iron and lead. Metals such as copper and bronze are more corrosion resistant, than the iron based metals. In many cases nonmetallic materials may be used in place of metal.

Where possible, use the same metal in the whole system to stop the action caused by dissimilar metals. When you must use dissimilar metals, use those as close together on the electromotive series chart as possible. The closer two metals are, on the E.M.F. series chart, the slower the rate of corrosion. See figure 7 for the E.M.F. series chart. The top of the chart is the most corrosive metals and progresses to the least corrosive metals at the bottom of the chart.

EXERCISE I-7-7a

INSTRUCTIONS

Use SW J3ABR56631 000-I-7 to complete the following statements.

1. What is corrosion? ______________________________

____

2. What is the most common type of corrosion? ____________________

3. What are the four requirements needed for galvanic corrosion to occur?

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

4. How can galvanic corrosion be prevented? ______________________________

____

5. Name the four types of corrosion that appear on iron.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

6. Explain how painting protects metal objects from corrosion. ______________

____

____

7. In what portion of a galvanic cell does corrosion occur? ______________

____

8. What is the meaning of EMF? ______________________________

____

9. When connecting a brass fitting to a steel pipe, which is most likely to corrode first? ______________________________

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

Cathodic Protection

Another method used to stop or slow down corrosion is cathodic protection. Cathodic protection, by definition, is the use of the right amount of direct current to stop currents from leaving the anodic areas of a metal structure. The whole object then becomes negative (cathodic) to its surroundings. With this in mind, we can use the knowledge of the electromotive potential of a metal and impress a current to make the object have less electrical potential than another metal with which it is in contact.

Cathodic protection may be used to (stop or slow down the) corrosion of any metal surface which is in contact with an electrolyte. It may be used on buried metal surfaces such as steel pipelines and metal storage tanks. It may also be used to protect the bottom of storage tanks built on the ground, the inside surfaces of water tanks and other metal structures in water.

THEORY OF CATHODIC PROTECTION

If the flow of current between the cathode and the anode can be stopped, or its direction changed, in theory, the metal will not corrode. In cathodic protection, the current flow is slowed down by passing a current through the electrolyte to the metal to be protected.

METHODS OF CATHODIC PROTECTION

The use of sacrificial anodes is one means used to cause current flow (galvanic method); the use of an impressed current is another means.

Sacrificial Anode System

To get cathodic protection by the sacrificial anode method, a metal that is more prone to corrosion than the one being protected, is put in the electrolyte and connected to the object. Current will then flow from the more anodic or corroding metal, through the electrolyte to the metal for which there is a need to be protected. The connection between the two objects makes the circuit, and lets the current flow to the corroding metal. The corroding metal is the anode of this dissimilar metal cell, and the metal which needs protection is cathode. The position of the metals in the electromotive series determines which way the current will flow. The current from the sacrificial anode is strong enough so that no current will leave the metal that needs protection. Since the cathodic protection currents flow from the electrodes, they act as sacrificial anodes and will be destroyed in time. The protected metal is cathodic, or negative to its surroundings, until the sacrificial anode is completely destroyed.

Metals such as magnesium and zinc which are higher on the electromotive series chart have been found to be very good sacrificial anodes when used with iron. Iron, on the other hand, is an anode when used with copper. For large structures or pipe systems, cathodic protection by the galvanic method is not economical and a direct current must be used.

Impressed Current System

To get protection by the impressed current method of cathodic protection, direct current from a source such as a wet or dry cell battery, rectifier, or generator must be used. The positive side of the circuit is connected by an insulated wire to the iron, carbon, or graphite electrodes buried near the structure. If it is a water tank, the electrodes will be in the water. The negative side of the circuit is connected to the structure. The power source is used to force the current through the ground (or water) to the structure and then back to the power source through the negative terminal. This current stops the normal flow of galvanic current from the structure. Figure 7-5 shows this form of protection.

EQUIPMENT PROTECTED

Cathodic protection is limited in application and it cannot be used to stop corrosion in all situations. For instance, the outside surface of a buried pipe can be protected cathodically, but not the inside of the pipe. In an elevated storage tank or ground storage tank, only the inside surface that is submerged will be protected. The outside of the tank is protected from atmospheric corrosion by paint or other coatings.

Buried Pipelines

Buried pipelines are most commonly protected by use of the impressed current. It is necessary to force the current into the soil and, through it to the pipeline being protected and then send it back to the source.

The best way to do this is to bury scrap metal or carbon rods. See Figure 7-5. The current flow gives complete protection depending on many different factors such as, pipe coating, area of exposed metal, soil resistance, metal-to-soil potentials, potentials of anodic and cathodic areas, and the kind of metal in the structure. The main factor of these is the amount of metal that is exposed. For example, on a mile of bare 12-inch pipe with about 18,000 square feet of metal surface, 100 to 150 amperes of current might be necessary for good protection.

No hard and fast rule can be used, although for rough estimates, 0.003 amperes per square foot of bare surface is used for iron structures. When cathodic protection is used, the external current is applied until the pipe-to-soil potential drops to at least minus 0.8 volts. This is checked with a multimeter and a copper-copper sulfate half cell. When the protection is maintained, corrosion will be greatly reduced.

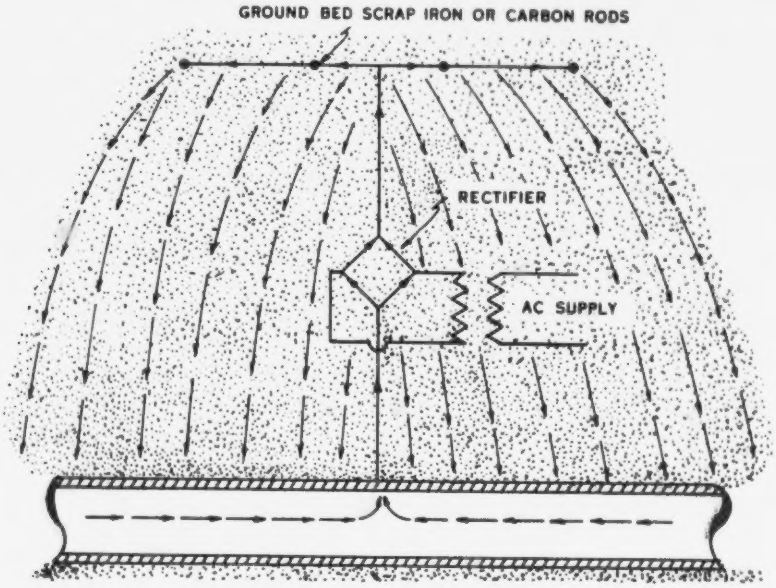


Figure 7-5. Cathodic Protection of Buried Pipeline Using External Power Source

Steel Water Storage Tanks

Cathodic protection stops corrosion by the flow of direct current to the tank wall in steel tanks. This is the reverse of current flow that is caused by corrosion. The equipment used will include a rectifier to change an AC source of power to DC, control rheostats, an ammeter, and electrodes hung from the roof of the tank and into the water. The electrodes are not connected to the tank bottom. The circuit is completed from the electrodes through the water to the tank. Current density must be about 5.0 milliamperes per square foot of bare metal; less if the metal has a coat of paint on it. It is essential that the electrodes be hung at different levels throughout the tank to maintain adequate protection. It may be necessary to hang the electrodes in a circle in large tanks, for good protection. The riser (if any) will have an electrode in it to within a few feet of ground level.

A great deal of emphasis is placed on the intermittently submerged surface of the tank. This and the area above the normal water line will corrode. It is for this reason that the entire interior of the tank must have a good coat of paint.

MAINTENANCE OF CATHODIC PROTECTION SYSTEMS

Impressed Current System

When the impressed current system is in operation, note and write down the current flow shown by the meters. If there is no current, check the fuse, electrodes, ground wire to tank or pipe, and immersion of the electrodes. Check polarity and direction of current flow. If the connections to the rectifier are reversed, rapid damage to the tank will take place.

Check the records and other data to be sure electrodes are covered with water. Keep enough water in the tank to cover the electrodes.

Check deterioration of electrodes. The amount of corrosion will increase as the size of the electrodes decrease. Replace electrodes that are badly corroded. Watch for a reduction in current flow which is a sign of a worn or failing electrode, (sacrificial anode).

Protect the electrodes in elevated storage tanks from ice, which may damage them or tear them from their mounts. If ice is a problem, the only way to protect them is to take them out when it is cold; put them back in at the end of the cold weather.

To test the equipment, drop the water level and remove the paint from a spot on the wall. Check this spot every three months to see if the protection is good.

Prevention of Corrosion

Since you know that the requirements for a corrosion cell are an anode, a cathode, an electrolyte, and an electrical path, it is apparent that to stop corrosion, it will be necessary to take away one of the requirements. Methods used to do this are as follows:

1. Use only corrosion resistant materials.

2. Do not make galvanic cells by connecting dissimilar metals, such as iron and copper, together.

3. Use insulated couplings when such couplings must be made, to break the path of electron flow.

4. Do away with the electrolyte.

5. Use cathodic protection to do away with all anodic areas.

6. Paint the equipment to stop the electrolyte from contacting the surface of the metal.

Of all the methods used to stop corrosion, the one most used and the most practical way to stop corrosion is paint or some other type of coating.

There are many types of coatings used for this purpose. Asphalt, coal tar, plastic, mastic, grease, and concrete are a few. These are insulating materials, and are used to insulate or isolate the metal from the electrolyte and stop corrosion.

All of these coatings are not good for all environments, but each one can be used for certain types of corrosion environments. The list below shows some of the coatings and their uses.

Metallic coatings, such as zinc galvanizing is effective in protecting metallic structures or pipe from atmospheric type corrosion. This type of coat is for cold water lines and metals that are exposed to normal temperatures. However, at high temperatures, metals such as iron will rust rapidly. The reason for this is that at a temperature of approximately 140°F, iron becomes anodic to zinc. This will cause the iron to become the sacrificial anode which rusts readily.

Portland cement coatings have been used with success when used on pipes to be laid in corrosive soils such as areas that have acid mine drainage or in a salt marsh. Well mixed portland cement, of about a 1 to 2 mix is applied to a pipeline. The coat of cement may be up to two inches thick. If the cement is properly mixed and tamped around the pipe, it may last for forty years. However, cement will absorb moisture and crack, in many ways this will limit its use. In fact, where the cement cracks, electrolysis will start to corrode the material. This corrosion can be reduced by painting the pipe with a bituminous primer before coating or by grounding the pipe, and by filling the cracks with asphalt or coal tar.

The portland cement coating previously discussed is used on the outside of pipes to stop corrosion. Portland cement coatings are now being used on the inside of pipes by a process known as the centerline process. This involves cleaning the pipeline and coating the interior with a layer of concrete. The process can be used on pipe with a diameter of four inches or more.

Grease coating is another type of coating used on pipes. This grease is made from a petroleum base and looks like wax. It can be applied either hot or cold; however, it must be protected by some type of wrapping to keep the grease from being absorbed by the backfill soil.

Asphalt and coal base coatings are by far the most common types of coatings used. Asphalt base coatings are made from petroleum. These coatings can take a lot of abuse and temperature change without creating a corrosive condition. However, a coat of this type absorbs water and dissolves to form other petroleum products. Some types of asphalt coats are more expensive than coal tar.

Coal tar coatings are the most common type used on pipes today. It has been proved that these coatings last longer, and they have continuity, hardness, adhesion, and resistance to corrosion. Coal tar coatings are less expensive than asphalt base coatings. This type of coating has the disadvantage that it does not have a very good impact resistance, and a wide change of temperature will often cause the surface to crack.

Another group is the paint and enamel coatings. Coal tar, asphalt, rubber, and vinyl are just a few of the paints used to coat metal surfaces to protect them from corrosion.

Coal tar paints can seal out water and will not breakdown from the effects of water, this resists electrolytic reaction. These paints are used on piers, flood control structures, sewage disposal plants, and industrial concrete pipes.

Asphalt based paint is weather resistant and will resist industrial fumes, condensation, and sunlight; since it has a high resistance to water, it is used on steel tanks and concrete reservoirs.

Rubber based paints such as the chlorinated rubber base type are resistant to acids, alkalies, salts, alcohols, petroleum products, and inorganic oils. Resistance to these products makes this type of coating good for use on the inside of metal and concrete tanks. If these structures are built in water or under the ground, a special form of this paint must be used to fight condensation.

Vinyl type paints are some of the many synthetic resin base paints. This paint dries to a film that is tough and resistant to electrolysis. The film is not harmed by oil, fat, wax, alcohol, petroleum solvents, formic acid, organic acids, amonium hydroxide, and phenols. This makes it good for use on tanks, pipes, well heads, off-shore drilling rigs, pipes in the oil industry, railroad hopper cars, dairy and brewery equipment, storage tanks used for acids and alkalies, gasoline storage tanks, and concrete exposed to corrosion.

Most paint coatings or bonding material must have a thin layer of primer so it will fill the pores of the metal and stick to both the metal and the paint.

Preparation of Surfaces for Protective Coating - The protective coating fails in direct proportion to the lack of adhesion to the surface. Hence, it is important that the surface is clean to be sure that the paint will stick.

The surface preparation methods fall into three basic classes as follows: mechanical surface preparation, chemical surface preparation, and solvent cleaning and degreasing.

Mechanical Surface Preparation

Hand cleaning is the best way to clean spots and is not good for use on large areas. The cleaning is done with a wire brush, sand paper, scrapers, knives, chisels, and hammers. Hand cleaning is for the most part used to take off loose scale, paint film, and caked soil.

Power cleaning works better than hand cleaning on large areas. Power tools may be pneumatic or electric grinders, sanders, and brushes which can take off corrosion down to the bare metal. You should remove oil and grease with a solvent before you clean with tools to stop the spread of these products over the whole surface.

Sand or shot blasting is a mechanical means used to take off mill scale, rust, and rust scale down to the base or white metal. The process involves abrasives shot under high pressures against the surface of the metal to be cleaned. For best results, the surface should be primed immediately to stop corrosion on the crater-like surface depressions, ridges, or metal hairs caused by sand blasting.

Flame cleaning is another way to clean surfaces and is used where it will not cause a problem if the surface works or dries out. Flame cleaning is used to take off unbonded mill scale and old mill scale which had not been painted. A flame cleaned surface must have paint on it before it is affected by condensation, this is generally done within two hours after flame cleaning while the metal is still warm.

Chemical Cleaning

The second method used to clean a surface is by the use of chemicals. Chemicals will include alkali, acid, steam, and phosphates.

In the alkali treatment, a strong alkali is used to take off oil, grease, and some types of rust. Alkali does not take off heavy or carbonized oils, or rust inhibitive oils. The surface must be neutralized with a weak acid so that the alkali does not attack the primers, after the alkali treatment has been used.

Acid pickling is another type of chemical treatment of metal surfaces. A weak acid such as a diluted muriatic acid is used on grease free iron or steel to take off all mill scale and corrosion. Weak phosphoric or chromic acid is used soon after the acid cleaning to protect the surface. When the surface is dry, a protective coat of paint is put on to give a more permanent coat on the surface.

Steam can be used to take off dirt, grime, grease, and loose paints, but it does not take off rust or mill scale. Detergent steam cleaning has been used with good success to take off grease. After steam is used, the surface is rinsed so that the alkali on the surface does not attack the prime coat.

The phosphate treatment is a chemical process used to treat the surface with an insoluble metal phosphate which will give long life to the paint used. The surface must have been treated by some means to take off the corrosion prior to the phosphate treatment, since the metal phosphates have no effect on corrosion. These phosphates give long life to the paint film by improving adhesion, retarding underfilm corrosion, reducing electrochemical reaction, and reducing the decomposition of the paint. This treatment can be put on by immersion, with a brush, or with a spray. Care must be used when the chemical methods are used for cleaning, since some of the chemicals are hazardous.

Solvent Cleaning and Degreasing

The third method used to clean a surface is the solvent cleaning and degreasing method. Solvent cleaning is used to dissolve oil and grease but does not take off rust, mill scale or corrosion. The fire hazard and toxicity of solvents must be observed when this type of treatment is used.

Application of Protective Coatings

Technical Order 1-1-8 deals with application techniques, paint equipment, surface preparation, and a discussion of individual coatings. To provide the best protection for corrosion, the best treatment (combination of pretreatment, primer, and topcoat) must be used for each specific case.

The selection of the best treatment will depend on the material to be coated, the environment to which the item will be subjected, and the service life requirement of the coating. No one coat or coating system can work best in all cases. For example, a phenolic paint which meets Specification MIL P-12507 is good for water immersion or when the humidity is high, but poor for exposure to an industrial atmosphere.

Many primers and topcoats can be used in various combinations; however, some primers are made for a particular type of topcoat. The coating systems presented in Air Force Technical Order 1-1-8 adequately cover most Air Force painting requirements.

EXERCISE I-7-7b

INSTRUCTIONS

Use SW J3ABR56631 000-I-7 to complete the following statements.

1. What are the two systems used in cathodic protection?

   a. ______

   b. ______

2. Identify three items that can be protected by cathodic protection.

   a. ______

   b. ______

   c. ______

3. Where can cathodic protection be used? ______

   ______

4. What is the most important step in applying protective coatings? ______

   ______

5. In a galvanic cell which metal would have the highest electromotive force, the anode or the cathode? ______

   ______

6. What kind of surface preparation is steam cleaning? ______

   ______

7. What is the most commonly used protective coating today? ______

   ______

8. What factors determine the selection of the proper coating of a metal? ______

   ______

9. What is the purpose of cathodic protection? ______

   ______

10. In which direction must the current flow in order to protect the metal?

    ______

    ______

11. How often is the interior of a water tank checked for cathodic protection?

____

12. What is the copper-copper sulfate half cell used for in cathodic protection?

____

____

13. How is the inside of the riser on an elevated storage tank protected?

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

Corrosion is the deterioration of metal and can occur because of direct chemical attack or by an electrochemical reaction. Most corrosion is caused by electrochemical reaction. A corrosion cell will be created when there is an anode, cathode, electrolyte, and metal path present at the same time.

The best way to prevent or control corrosion is to eliminate any one of the necessary elements of a galvanic cell. This can be done in many ways, but the most practical way is the use of a protective coat of paint or other insulating material to keep the metal object from coming into contact with the electrolyte.

There are many different types of protective coatings, but all of these are not effective for all environments. For this reason you must have an understanding of the type of coating and the environment in which you would use each coating.

Cathodic protection is a method used to prevent corrosion of both new and old structures. It is usually the only sure method that can be used to stop corrosion on underground structures. The use of impressed current reduces the rate of corrosion of metal surfaces in contact with an electrolyte. It does this by making the metal structure cathodic to its environment. The two methods by which cathodic protection may be applied are, the sacrificial anode system and the impressed current system. The anodes must be made of a metal higher on the EMF series chart than that of the metal being protected.

REFERENCES

1. AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems.

2. AFR 91-26, Maintenance and Operation of Water Supply, Treatment and Distribution Systems.

3. TO 1-1-8, Application of Organic Coatings

4. TO 1-1-2, Corrosion Control and Treatment for Aerospace Equipment.

5. Elements of Chemistry, By Russell T. DesJordin

6. Introduction to Metallic Corrosion, By Ulick R. Evans

7. Corrosion Causes and Prevention, By Frank N. Speller, DSC

3770 Technical Training Group
(Civil Engineering Training)
Sheppard AFB, Texas

SW J3ABR56631 000-I-8

HAND AND SPECIAL TOOLS

OBJECTIVES

Given a list of tasks and a list of tools, select the tool that should be used to complete each task.

Given an electric grinder, a checklist and handtools, perform the required inspection and maintenance on the grinder with no more than one instructor assist.

INTRODUCTION

Some of your duties will require you to use handtools. In order for you to use and maintain handtools in the proper manner, there are some facts that you must know.

The information will be presented under the following headings:

* Types of Common Handtools

* Use of Tools

* Tool Safety

* Care of Tools

* Tool Inventory

* Electric Grinder

INFORMATION

TYPES OF COMMON HANDTOOLS

Screwdrivers

One of the most commonly used handtools is the screwdriver. It is used to tighten or loosen screws. Screwdrivers have three main parts: the handle, shank, and blade. These parts are shown in figure 8-1.

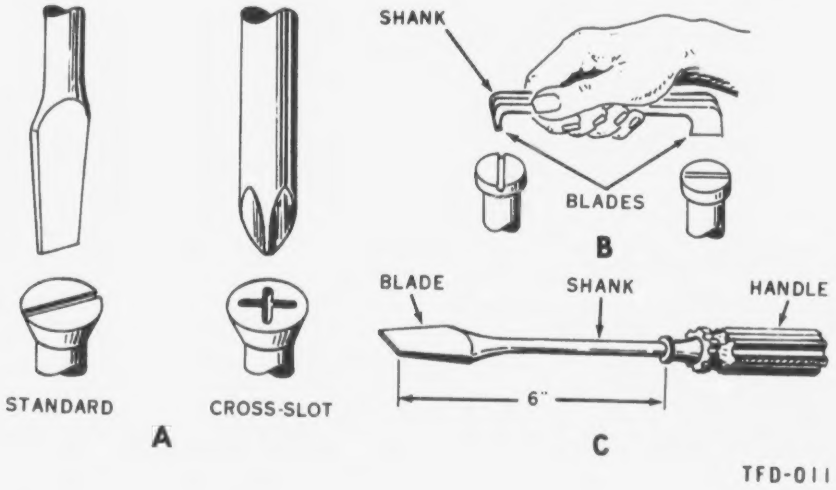


Figure 8-1

When you select a screwdriver for a job, you should use one that has the proper size of blade tip. The blade tip must fill the slot of the screw in both width and depth and should also fill most of the length of the slot. See figure 8-2.

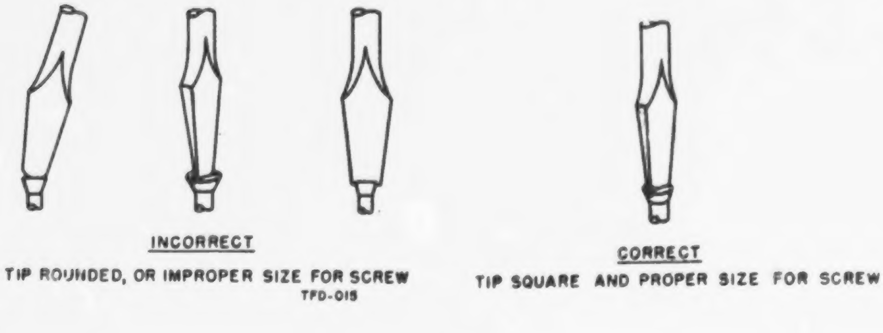

INCORRECT
TIP ROUNDED, OR IMPROPER SIZE FOR SCREW
TFD-015
CORRECT
TIP SQUARE AND PROPER SIZE FOR SCREW

Figure 8-2.

Hammer

Another handtool that you may be required to use is the hammer. All hammers are not the same. Some of the different types of hammers are shown in figure 8-3.

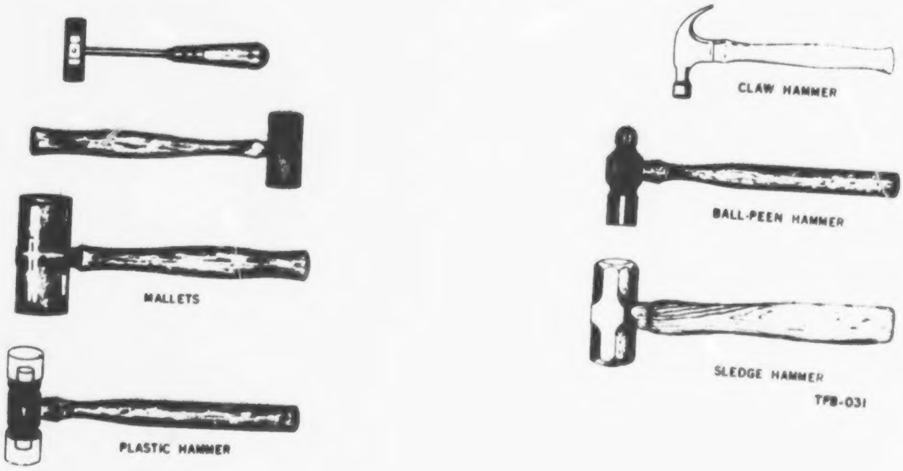

MALLETS
PLASTIC HAMMER
CLAW HAMMER
BALL-PEEN HAMMER
SLEDGE HAMMER
TFB-031

Figure 8-3.

Pliers

There are many different types of pliers. The combination, adjustable (water pump), long-nose, flat nose, and side-cutting are just a few. All of these tools are shown in figure 8-4.

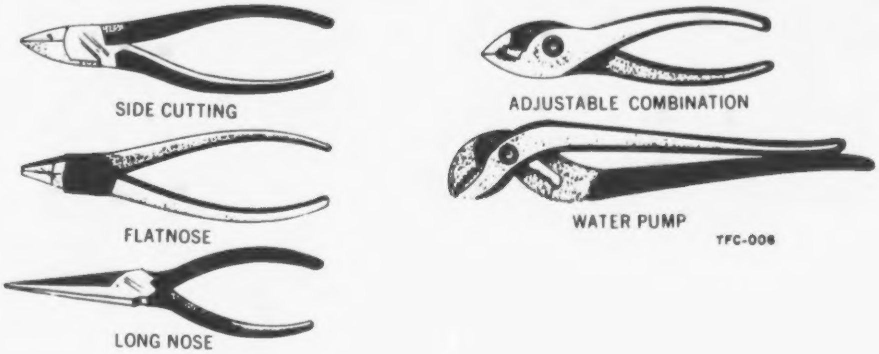

SIDE CUTTING
ADJUSTABLE COMBINATION
FLATNOSE
WATER PUMP
TFC-006
LONG NOSE

Figure 8-4.

Wrenches

A good mechanic must know the proper wrenches to use on a job. Some of the types of wrenches you may use are the allen, box-end, socket, adjustable, combination, and open-end. See figure 8-5.

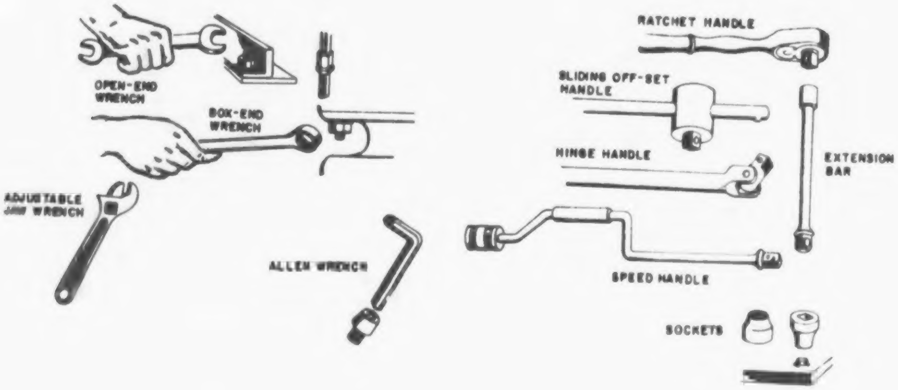

OPEN-END WRENCH
BOX-END WRENCH
ADJUSTABLE JAW WRENCH
ALLEN WRENCH
RATCHET HANDLE
SLIDING OFF-SET HANDLE
HINGE HANDLE
EXTENSION BAR
SPEED HANDLE
SOCKETS

Figure 8-5.

Hacksaw

Another handtool that you may have a need to use is the hacksaw. The hacksaw consists of two parts: the frame and blade as shown in figure 8-6.

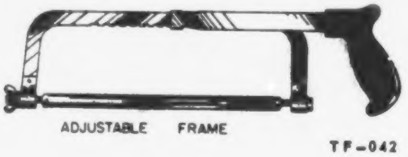


Figure 8-6.

Hacksaws are used to saw round or flat metal, such as pipe or sheet metal.

USE OF TOOLS

Every tool has a function. If you use the wrong tool for the job, you could injure yourself or damage the tool. You will learn the correct use of each tool as you complete a workbook on handtools.

SAFETY OF TOOLS

Handtools, no matter how simple they are, can be the cause of an accident. This is especially true if the tool is not used properly or the tool is not in good repair.

All handtools should be of good quality, adequate for the job, and used only for their intended purpose. Be sure to use the correct tool for a particular job.

Objects on which you are working with a sharp instrument, such as a screwdriver, you should not hold the work in your hand or on your lap. All work should be placed on a flat surface or held in a vice, and when finished with a vice the jaws should be loosely closed.

A tool with a "mushroom" head, such as a cold chisel or punch, should not be used because metal chips are apt to fly from the mushroom head when it is struck with a hammer. Grind off the mushroom head before use. Always remove jewelry and wear eye protection to protect yourself from injury.

CARE OF TOOLS

Tools tell a great deal about their user. Dirty, greasy, or rusty tools are the mark of a shade-tree mechanic. This type individual spends a great deal of time just looking for a workable tool. The work area is seldom cleaned.

Tools properly placed, cleaned and oiled and in good sound working order are the mark of a skilled specialist. There is a place for every tool, and every tool is in its place. Tools should be in good operating order and ready for use. The work area should be clean and orderly.

TOOL INVENTORY

After a job is finished the tools should be given a complete inventory. You are probably wondering why you must inventory your tools. It is very simple; tools cost money, there must be a direct line of responsibility. If a person is not held responsible for their tools, they will not take care of them.

Another reason for the tool inventory is to make certain you did not leave a tool at the job site. This could cause considerable damage to equipment if undetected.

EXERCISE I-8-8a

PART 1

INSTRUCTIONS

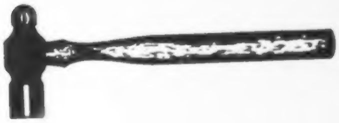
Use SW J3ABR56631 000-I-8 to complete the following matching exercise. Match Column A with Column B.

COLUMN A

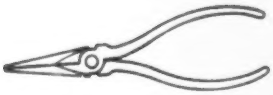
1. Vice-Grip Pliers ____________
2. Standard Screwdriver ____________
3. Ball-Peen Hammer ____________
4. Slip-Joint Pliers ____________
5. Long Nose Pliers ____________
6. Plastic Hammer ____________

COLUMN B

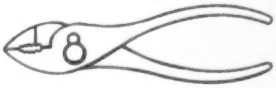
a.



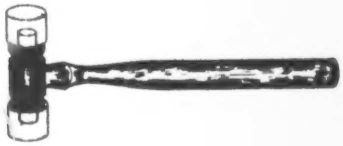
b.



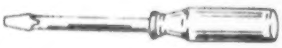
c.



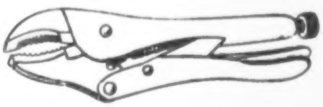
d.



e.



f.



PART 2

INSTRUCTIONS

Use SW J3ABR56631 000-I-8 to complete the matching questions. Match Column A with Column B.

COLUMN A

1. Phillip Screwdriver __________
2. Universal Joint __________
3. Adjustable __________
4. Slip-Joint Pliers __________
5. Ball-Peen Hammer __________
6. Long Nose Pliers __________

COLUMN B

a. What tool is used for an extra set of fingers?

b. What tool is used for tapping on light metals?

c. Used on small pieces of metal which cannot be reached with the fingers.

d. Allows you to apply a force from different directions. It is used between the socket and socket handle.

e. What type tool is used for a cross head?

f. When no other wrench will fit a nut or bolt you may have to use this type of tool.

PART 3

INSTRUCTIONS

Use SW J3ABR56631 000-I-8 to answer the following questions.

1. Name four common handtools? ______________________________

____

2. List the three main parts of a screwdriver. ______________________________

____

3. Name three different types of pliers. ______________________________

____

4. What is the purpose of a hacksaw? ______________________________

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

ELECTRIC GRINDER

Bench Grinder. The bench grinder is a tool used for grinding operations. These include sharpening chisels, screwdrivers, drills, and punches. They are also used to remove excess metal from work and smooth metal surfaces. It is usually fitted with both medium- and fine-grain abrasive wheels. These wheels may be removed and other wheels substituted for them. Such wheels may include wire brushing wheels, buffing wheels, or polishing wheels.

Before you operate a bench grinder, look at the unit to identify any hazards or maintenance needed. Look for such things as: the electrical cord freying; the ground on the plug must be there; the casing must not be cracked or damaged; the eyeshield and tool rest must be the there and tightly secured; any loose connections must be tightened; the grinding wheels must be firmly held on the spindles by the flange nuts, these must be tight; the grinding wheel must be dressed and must not wobble; and the grinder must be secured to the floor or bench.

During the operation, first listen for unusual noises then check for odors. If any unusual noises are found find the cause and fix it if possible. The work should be held firmly at the correct angle on the tool rest provided. Next feed the work into the wheel with enough pressure to remove the desired amount of metal without generating too much heat. If too much heat is generated by the grinding, cool the tool by dipping in water to cool it.

Remember, the abrasive wheel which grinds metal easily, grinds human fingers more easily.

NOTE: If wheel needs dressing, follow these steps:

1. Adjust tool rest to permit wheel dresser to contact abrasive wheel on center lineof wheel.
2. Start wheel revolving, then support the dresser on tool rest with handle tilted upward at angle.
3. Slowly press the wheel dresser against face of revolving wheel until it "bites" then move dresser from side to side across wheel to obtain a straight surface on the wheel. CAUTION: Hold the dresser rigidly enough on tool rest to prevent vibration.
4. Smooth wheel by passing an abrasive type dresser back and forth over the face of the wheel, smoothing with a very light pressure.

If you need to dress the wheel, refer to the NOTE above or to TO 30-1-101. For more maintenance information, refer to the manufacturer's manual.

EXERCISE I-8-8b

INSTRUCTIONS

Using the electric grinder, inspect and repair as required.

a. To test the grinding wheel, tap it with a ball-peen hammer. Yes No

b. When tapped, a dull thudding sound indicates an operational wheel. Yes No

c. Is the grinder securely anchored to the floor? Yes No

d. Is a face shield used with the grinder? Yes No

e. Is the wheel properly dressed? Yes No

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

It isn't a pretty sight to see you loose a finger, hand, arm, or your own life because you have bad habits or a "don't care" attitude when you use hand or power tools. No one likes to tell you that they don't want to work with you because of your poor work habits. A mechanic, who keeps his tools in good repair and works in a safe manner will always get willing help when they need it.

REFERENCES

TO 30-1-101, Maintenance and Care of Handtools

OPERATION AND MAINTENANCE OF WATER AND WASTEWATER TREATMENT SUPPORT EQUIPMENT

OBJECTIVES

Given four control devices, identify, inspect, and state the function and operation of each.

Identify the purpose, operating features and operator maintenance requirements for air compressors. Three of the five must be correct.

Using AFR 91-26, list the purposes, types, and inspection procedures of water storage tanks.

Given a set of incomplete statements about various valves, make written responses to identify each valve. Seven of the ten must be correct.

Given a check valve, disassemble, inspect, and reassemble the valve with no more than one instructor assists.

Using a gate valve on the pump trainer, remove and replace the valve packing to prevent water leakage with a maximum of two instructor assists.

Using AFR 91-26 and information pertaining to electric motors and power connectors, list the operational checks and operator maintenance requirements for motors and connectors.

Given information pertaining to chemical feeders, identify the three types of chemical feeders by completing written statements.

Given chemical feeders and working as a team, disassemble, inspect and reassemble the feeder to operating condition with a maximum of five instructor assists.

Given information pertaining to different types of measuring devices, write the function and application of each and record a meter reading. Five of the seven must be correct.

Given a water meter, disassemble, inspect and reassemble the meter using a checklist or manufacturer's brochure with no more than one instructor assist.

Monitor the operation of selected backflow preventers and list four methods of backflow prevention with no more than two instructor assists.

Given four types of backflow preventer malfunctions, select the maintenance required to correct the malfunction. Three of the four must be correct.

Using AFR 91-26, list three operational services which are common to standby engines.

Given a list of pump types and a list of pump characteristics, match the pump type to its characteristic. Three of five answers must be correct.

Using the sewage lift station trainer and working as a team, monitor/operate the trainer in accordance with the standard operating procedures with no more than two instructor assists.

Using the sewage lift station trainer, and working as a team, perform operat inspection and maintenance on the trainer in accordance with a checklist with no more than two instructor assists.

During a field trip to the base water and wastewater facilities, use a checklist to monitor and inspect the support equipment. Students checklist must correspond to 60% of instructor's evaluation of the facility.

CONTROL DEVICES

INFORMATION

All water systems need to be regulated. Control devices are used for this purpose. These devices are grouped under four headings; mechanical, electrical, hydraulic, and pneumatic.

TYPES OF CONTROL DEVICES

Mechanical

Mechanical control devices operate through a mechanical linkage. This type of device is normally used to control the liquid level in a tank or other container.

Electrical

Electrical control devices have been designed for many different functions. Electrical control devices are designed to open or close an electrical circuit or to adjust the operation of a piece of equipment. They may be very simple in operation such as in a float switch or highly complex as in a probe which will detect the temperature, chlorine residual, or pH in a water storage tank. The various designs are too numerous to discuss here. It will be your responsibility to learn about the types in use where you are assigned.

Hydraulic

Hydraulic controls use fluid pressure and a diaphragm to operate. The controlling pressure may be provided from an outside source or extracted from the system being controlled.

Pneumatic

Pneumatic control devices are very similar to hydraulic devices except that they use compressed gas pressure instead of fluid pressure to operate the control. Although air and nitrogen gas are the most common, other gases may be used.

FUNCTIONS AND OPERATION OF CONTROL DEVICES

Mechanical

A very common mechanical control device is used in the toilet in your home. By using a float that rises and falls with the level of the water in the tank, the flow of water can be controlled. When the level is low the float falls opening a valve allowing water to refill the tank. When the water reaches the desired level, the float closes the valve, stopping the flow of water. Mechanical control devices may also use spring tension or weights to control the level in tanks. A typical mechanical control device is shown in figure I-9a-1.

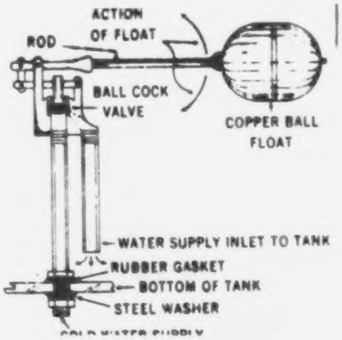


Figure I-9a-1

Electrical

Using a sensing element such as a probe or a pressure switch, a pump may be started, stopped or adjusted automatically to maintain water system pressure. An electrical probe may also be used to control a particular condition of the water. For example, if the temperature of the water in a heated swimming pool is low the probe sends a signal to the heater which in turn heats the water. The control device in figure I-9a-2 is a float switch. The float activates the electrical switch which controls a piece of equipment such as a pump.

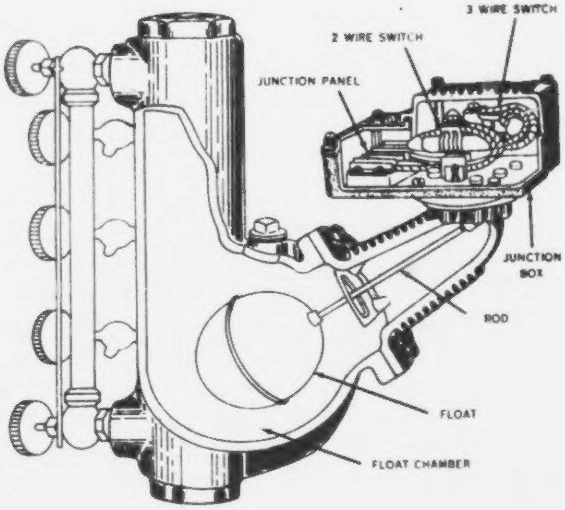


Figure I-9a-2. Electrical Control Device

Hydraulic

When a large amount of pressure is being used to hold a valve in position, a hydraulic control device is being used. Since pressure is equal on all sides of this control, it is easy for the valve to open or close.

Hydraulic control devices are very common. They provide an easy and accurate control over system pressure, filters and other water and wastewater plant equipment. A typical hydraulic control will use a diaphragm which has a larger surface area on one side than the other. The diaphragm is connected to a device which opens or closes a valve. A common type of hydraulic control has a sensing line which connects system pressure to one side of the diaphragm so that pressure on both sides of the diaphragm are equal. Control is obtained because of the difference in the area of the sides of the diaphragm. A slight adjustment in the pressure on the smaller area side will result in a large change in pressure on the other side. A hydraulic control device is shown in figure I-9a-3. It uses system pressure to operate. The sensing line in this control device is the pilot tube.

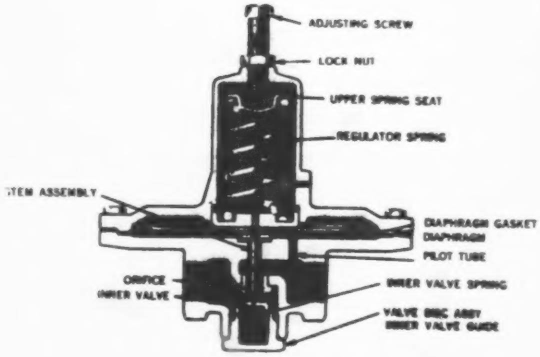

ADJUSTING SCREW
LOCK NUT
UPPER SPRING SEAT
REGULATOR SPRING
STEM ASSEMBLY
DIAPHRAGM GASKET
DIAPHRAGM
PILOT TUBE
ORIFICE
INNER VALVE
INNER VALVE SPRING
VALVE DISC ASSY
INNER VALVE GUIDE

Figure I-9a-3. Hydraulic Control Device

Pneumatic

For a pneumatic control device to operate, compressed gas must be supplied to the controller at a constant pressure. The controller is connected to a valve, a damper or other piece of equipment to operate it. The pneumatic control device applies a variable pressure to the piece of equipment being controlled according to the variation in the condition being controlled. Basically, the pneumatic control device is an automatically adjusted pressure reducing valve. Figure I-9a-4 shows a pneumatically controlled system.

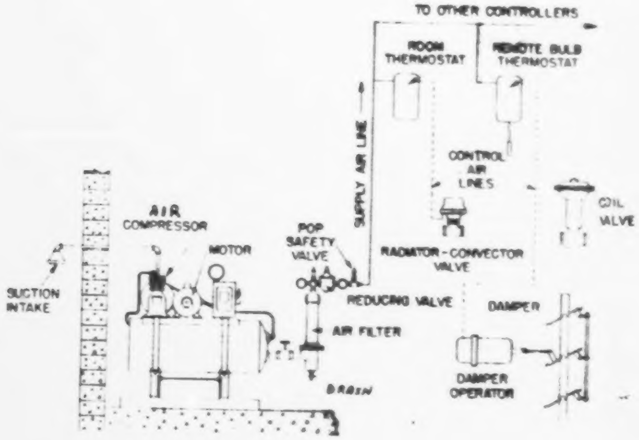

TO OTHER CONTROLLERS
ROOM THERMOSTAT
REMOTE BULB THERMOSTAT
SUPPLY AIR LINE
CONTROL AIR LINES
COIL VALVE
AIR COMPRESSOR
MOTOR
POP SAFETY VALVE
RADIATOR-CONVECTOR VALVE
SUCTION INTAKE
REDUCING VALVE
DAMPER
AIR FILTER
DRAIN
DAMPER OPERATOR

Figure I-9a-4. Pneumatically Controlled System

PREVENTIVE MAINTENANCE PROCEDURES

A good, sound, well organized and energetically pursued preventive maintenance program will provide a tremendous cost savings over a long period of time. This program should include but not be limited to; lubrication, cleaning and testing of the control device. The unit you are assigned to should have technical publications covering the specific control devices installed at your base. These publications should be consulted to perform maintenance on the devices. Listed below are a few general maintenance guidelines for control devices.

Mechanical

Most mechanical devices have pivot points which require cleaning and lubrication. The device should be inspected for proper alignment, freedom of movement (too close to the tank wall), and corrosion.

Electrical

Electrical controls also need cleaning from time to time. Those that use mechanical linkage must also be checked for lubrication and corrosion. Some electrical control devices may need calibration after repair or at certain intervals. Check with the manufacturers manual to see if you are able to do the calibration, otherwise report it to your supervisor. Be sure to check electrical connections to insure they are free of corrosion and secure.

Hydraulic

Hydraulic control devices may have mechanical linkage which needs to be checked. Hoses and tubes must be inspected for leaks, loose supports, wear and general condition. The diaphragm on the control device must also be inspected for cracks, tears, and general condition.

Pneumatic

Pneumatic systems require a source of air or gas to operate. Check hoses, tubing gas cylinders and components for secure mounting, leaks and corrosion. If an air compressor is used to supply the air for the control device, maintenance will be required for the air compressor also. We will cover maintenance of air compressors in the next section.

SUMMARY

Control devices are essential pieces of support equipment for the environmental support career field. Knowledge of how they operate and the maintenance procedures for them will keep the control devices in service for a long period of time.

EXERCISE I-9a

INSTRUCTIONS

Use SW J3ABR56631 000-I-9 to complete the following.

1. List the four types of control devices.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

2. Which type of control device uses a float valve to control the level in a tank?

   ____

3. Electrical control devices use a ______________ or a ______________ ______________ to start or stop a pump.

4. Pneumatic control devices use ______________ ______________ supplied at a constant ______________ to operate.

5. Hydraulic control devices use a ______________ with a larger ______________ ______________ on one side than the other.

6. Preventive maintenance on mechanical control devices should include ______________ ______________, and ______________.

7. Preventive maintenance on electrical control devices should include checking ______________ ______________ to insure they are secure and free from ______________.

8. Hydraulic hoses and tubing should be checked for ______________, ______________, ______________ and ______________ ______________.

9. Check pneumatic system ______________, ______________, and ______________ for secure mountings, leaks and corrosion.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

AIR COMPRESSORS

INFORMATION

Air compressors are used for a variety of different jobs at water and wastewater treatment plants. There are many different types of compressors, but the principles of operation of all of them are similar. Keep in mind that wherever you are working, there may be different types of air compressors. Your section should have technical publications for the units in use.

Purpose

Compressed air systems are used in water plants, lift stations, wastewater plants, and laboratories. Pneumatic control devices may require air compressors for operation. Valves at various points throughout the water system and treatment plants may be operated with air assistance. Pneumatic tools also use compressed air for operation.

Operating Features

The air is compressed in an electric, gasoline or diesel driven compressor and stored in a tank until needed. Air is drawn into the compressor, where it is reduced in volume and passed through a check valve into the storage tank. A combination pressure control and safety valve regulates the operation of the compressor and power unit. When the amount of air stored in the tank reaches the desired pressure the compressor shuts off automatically. If the pressure control fails to operate, a safety valve functions and relieves the pressure in the tank to prevent it from exploding. The compressor equipment is commonly housed in a centralized location. The location should be clean, dry, accessible and well ventilated. This will provide for proper operating conditions for the compressor.

Air compressors used in the Air Force are normally of two types; piston-type or the rotary-liquid type.

PISTON TYPE. Piston-type compressors are usually two stage compressors with the compression taking place in two distinct steps in separate cylinders. For shops, a single compressor is most often used, compressing and delivering air at pressures up to 100 psi.

ROTARY-LIQUID TYPE. Rotary-liquid type air compressors have a multi-bladed rotor revolving in a casing which is partially filled with a liquid. The rotor serves the same purpose as the piston in a piston-type compressor.

CONTROLS. Air compressors usually operate automatically. The operation is controlled by a diaphragm-type pressure switch. A pressure gage is usually located next to the pressure switch. Safety valves should be installed on the compressor components, such as the inter/after cooler, the air receiver (storage tank), and compressed air discharge lines.

AIR FILTERS. Each compressor has an intake air filter to prevent dirt and grit from entering the compressor. The filter also serves to muffle intake noises.

Operator Maintenance Requirements

It is very important that the water and oil in the air receiver and lines be drained daily. Water can cause water hammer in pipes and lines, reduced capacity of the lines and washing away of the lubricant in pneumatic tools. Water can also freeze in the lines in cold climate. In addition to draining this condensate, other daily maintenance procedures include; checking the system for air leaks, checking for loose drive belts, and checking the oil level in the air compressor. Other maintenance includes periodic checking of the inter/after cooler for cleanliness and an occasional cleaning of the air filter.

Problems which could cause inefficient operation in your air system include low compression and leaking valves. These are problems which you can prevent or delay with proper operator maintenance. However, equipment will eventually wearout and require major repairs. Major repairs are usually done by the people in the refrigeration shop, however, it may be different where you are assigned.

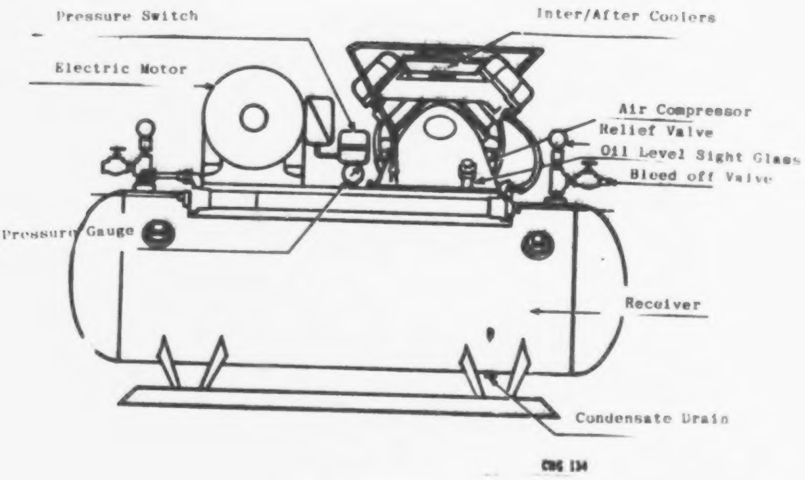

Pressure Switch
Inter/After Coolers
Electric Motor
Air Compressor
Relief Valve
Oil Level Sight Glass
Bleed off Valve
Pressure Gauge
Receiver
Condensate Drain
CDG 134

Figure I-9b-1. Typical Air Compressor

EXERCISE I-9b

INSTRUCTIONS

Use SW J3ABR56631 000-I-9 to complete the following.

1. Compressed air systems are used in ____________, ______________, _____________ and ______________.

2. Air is drawn into the compressor, reduced in ______________ and passed through a check valve into a __________________.

3. If the ______________ ______________ fails to operate a ____________________ ____________________ prevents the tank from exploding.

4. The air compressor should be located in an area that is _______________________, _______________, _______________, and _______________ ____________________.

5. The common types of compressors found in use in the Air Force are the __________ type and the ____________________ - ______________________ type.

6. Air filters prevent _________________ and ___________________ from entering the unit and muffle ________________ _____________________.

7. Daily maintenance of air compressors includes draining _______________________, checking for __________________ __________________, _____________________ ___________________ ____________________ and checking the _______________ level.

8. Major repairs on compressors are done by the ___________________ shop.

STORAGE TANKS

Purpose of Storage Tanks

Storage serves to equalize demand, improve flows and pressure and provide reserves for firefighting and power outages. The normal demand for a community varies considerably between night and day and different days of the week. For this reason it is important to equalize the demand. During low demand periods water is placed in storage for use during periods when demand exceeds the capacity of pumps, treatment plants, supply lines or the source.

Water in storage can be used to equalize distribution system pressure in response to varied flows. Elevated storage serves to keep a constant pressure on the system or to even out the distribution flow patterns.

Fire demand may have to be met at any time. Storage enables water to be supplied during emergency conditions resulting from fires, power failures, breakdown of supply pumps, failure of supply mains, flooding or other conditions that may result from natural causes, accidents or enemy action.

Types of Storage Tanks

Storage can be constructed in three different ways depending on the requirements of the system. They may be built on the surface of the ground, undergound, or elevated off the ground.

GROUND STORAGE. Ground storage tanks may be located at any point in the water system but are usually located near the point of production. Ground storage reservoirs should have waterproof covers to prevent contamination from airborne dust and bacteria, animals or birds. The cover also serves to safeguard against accidental drownings. If covered the reservoirs must be vented to allow the passage of air as the water level changes. The vents must be screened to prevent the entrance of birds, insects or animals. In cold weather climates it is important to check the screens to insure they are free of frost and ice. If ground storage tanks are used only for fire protection it may be necessary to operate the fire pumps to recirculate the water thus preventing freezing. Ground storage tanks may be made of steel, concrete or wood with steel and concrete being the most common.

UNDERGROUND STORAGE. Underground tanks serve the same basic purpose as do ground level tanks. Both types are commonly used to maintain the firefighting capability of a base. Underground storage tanks will be constructed in the same manner as ground level tanks. They will be vented and covered and constructed of concrete or steel.

ELEVATED STORAGE. Elevated storage is provided by means of elevated tanks that are supported on columns or legs. The tanks may be cylindrical, spherical, ellipsoidal, conical or other shapes. Steel is generally used for elevated tanks but concrete may also be used. Sometimes small temporary storage tanks may be constructed of wood. Water that is stored at higher elevations is generally used to maintain pressure on the system without the use of pumps. It is desirable to have at least 50 percent of all storage as elevated or high level storage in case of power outages or failure of supply mains.

Problems with freezing are more apt to occur in elevated tanks. To guard against freezing of water in the riser of the tank, cover the pipe in the riser of the tank with insulating material. In climates where insulation alone may not give adequate protection, hot water circulation or steam coils in the riser may be used.

Inspection Procedures for Storage Tanks

Inspection procedures for storage tanks are basically the same regardless of the type of tank in use. For specific procedures see AFR 91-26, pgs 228 and 229, Table 8-4.

EXERCISE I-9c

INSTRUCTIONS

Use SW J3ABR56631 000-I-9 to answer the following.

1. What are the three types of storage facilities for water? ____________________

____

2. What are the three purposes of storage tanks? ____________________

____

3. If storage tanks are covered what must be installed to allow for air passage?

____

4. How do you prevent birds, insects, and animals from entering the vents on storage tanks? ____________________

5. What procedures are used to keep water in ground storage tanks from freezing?

____

6. What are the two most common materials used to build storage tanks? ____________________

____

7. What is the simplest method to prevent water in the riser of an elevated storage tank from freezing? ____________________

8. How much of the total amount of storage should be stored in elevated tanks?

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

VALVES

Valves are the traffic cops in any kind of piping system. This study guide will deal with the purpose, types and components of valves. Remember that one manufacturer cannot copy anothers design exactly, so there will be minor differences even though valves look and function the same.

Purpose of Valves

Valves are devices used to stop, start, or regulate flow of liquid into, through, or from piping. Essentially, a valve consists of a body with an opening and a means of closing the opening with a disk or plug which can be tightly pressed against a seating surface or within the opening.

Types of Valves

There are four basic types of valves which are common in any piping system. These are: gate, globe, check, and plug valves. In the following information each of these types will be explained. There are other devices used to control flow in a piping system, such as regulators, and flushometers. These are modifications of a basic valve design.

Gate Valves. As the name implies, a gate valve has a gate which opens and closes across the path of flow. See figure I-9d-1 below.

Gate valves are used for services requiring infrequent valve operation and where the disc is kept either full open or full closed. When full open, the seat design of the valve permits the fluid to move through the valve in a straight line with a minimum restriction of flow and a minimum loss of pressure at the valve.

This type of valve is not suitable for a throttling operation (where the valve is kept only partly open), since the velocity of flow against the partly open valve disc may cause vibration and damage to the disc and seat surfaces.

In piping systems most large valves will be gate valves. So in a large piping system if flow must be regulated it is normally done by some other means.

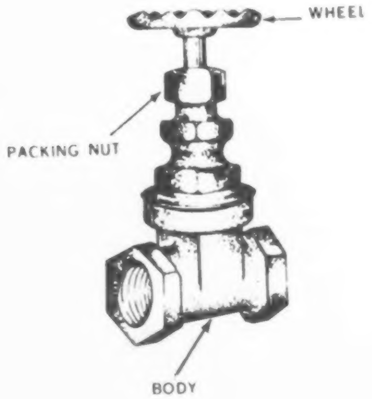
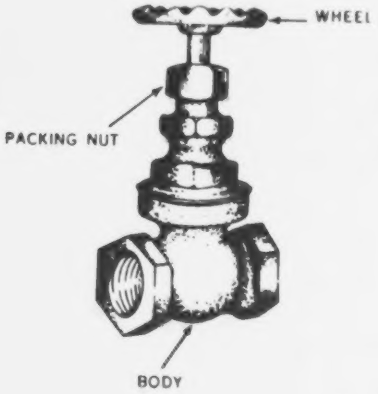


Figure I-9d-1. Gate Valve

NOTE: Two common variations of the gate valve are the ball and butterfly valves. These two types of valves are quick operating as they only require a 1/4 turn to open or close.

Globe Valves. The valves you are most familiar with are globe valves, such as; bath faucets, kitchen faucets, or hose connections. A globe valve is easily distinguished by its round bulging body. See figure I-9d-2. Due to their design a globe valve restricts flow and creates turbulence in the flow.

A globe valve has a horizontal interior partition which shuts off the inlet from the outlet, except through an opening in the partition. The lower end of the valve stem holds a replaceable fiber or metal disc shaped and fitted to close the hole in the horizontal partition. The valve is closed by turning the handwheel clockwise until the disc presses firmly on the opening. The volume of flow through globe valves is roughly proportional to the number of turns of the handwheel. The globe valve can be used for throttling flow.



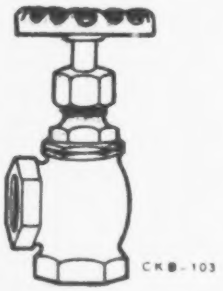


Figure I-9d-2. Globe Valve

Figure I-9d-3. Angle Valve

One common design of a globe valve is the angle valve. See figure I-9d-3. This adaptation allows an installation which reduces the number of fittings needed and the body design also reduces the amount of flow restriction.

Check valves. There are two types of check valves which we will discuss. These are the lift and swing check. The purpose of a check valve is to control the flow in one direction only. Check valves are not positive backflow preventers.

Swing check valves are designed with a disc (gate) that swings out of the way and is held there by the flow of water through the system. When flow ceases, the disc swings to the closed position by gravity force. (See figure I-9d-4) Swing check valves are normally installed in the horizontal position. If the flow is upward, they may be placed in the vertical position. The swing check valve is normally used with a gate valve as it offers little resistance to flow. Lift check valves are often used in a

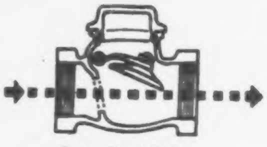
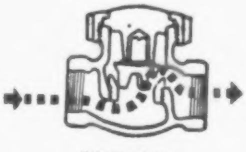


Figure I-9d-4

piping system and serve the same purpose as a swing check. A lift check should not be used in place of a swing check as it restricts flow like a globe valve, so it is normally used in line with a globe valve. If necessary, a swing check may be used in place of a lift check. A lift check can only be used in a horizontal position. See figure I-9d-5.



Lift Check Valve

Figure I-9d-5

Plug Valves. Plug valves like a gate valve offer very little restriction to flow as the flow is straight through. They offer one big advantage as it only takes 1/4 turn to open and close them. Most are designed so the handle can only go on in one position, this makes the handle line up with the pipe when the valve is open. Plug valves are often used in sludge lines. See figure I-9d-6.

Valve Components

The following figures identify the different valves with a breakdown of their components. Although we will not discuss all the components, the major items will be covered.

STEM. The stem is the component which connects the hand wheel to the gate or disc making it possible to operate the valve. Valves are furnished with rising stems or non-rising stems. A rising stem valve allows the stem to rise above the hand wheel as the valve is opened. A rising stem valve is also known as an indicating valve as you can tell if it is open or closed at a glance. (See figure I-9d-11)

GATES. In gate valves there are four different type discs in use. They are solid wedge, split wedge, double disc, and the flexible wedge. The system in which the valve is installed will determine the type disc to be used.

BONNETS. Look on the globe and gate valve at the top part labeled bonnet. There are three general types of bonnets used on valves. They are screwed, union and bolted. Most large valves have a bolted bonnet as it would be too difficult to maintain a water tight seal with either a screwed or union bonnet.

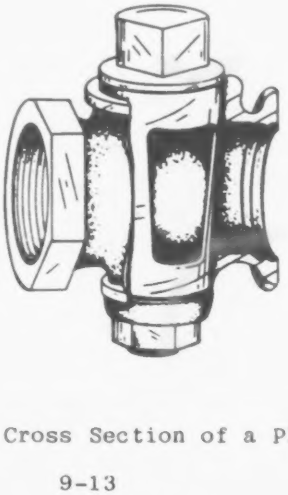


Figure I-9d-6. Cross Section of a Plug Valve

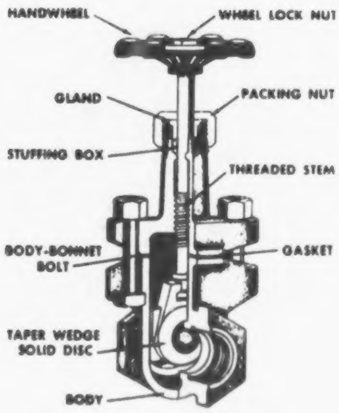

HANDWHEEL
WHEEL LOCK NUT
GLAND
PACKING NUT
STUFFING BOX
THREADED STEM
BODY-BONNET BOLT
GASKET
TAPER WEDGE SOLID DISC
BODY

Figure I-9d-7. Gate Valve

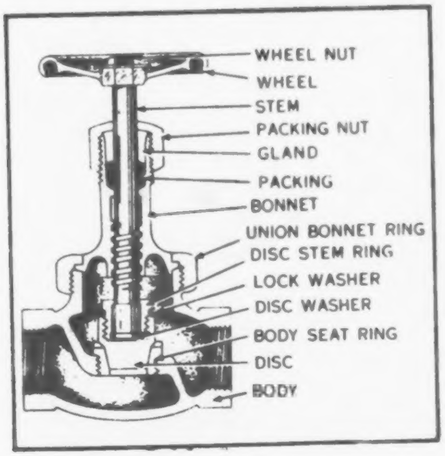

WHEEL NUT
WHEEL
STEM
PACKING NUT
GLAND
PACKING
BONNET
UNION BONNET RING
DISC STEM RING
LOCK WASHER
DISC WASHER
BODY SEAT RING
DISC
BODY

Figure I-9d-8. Globe Valve with Plug Disc.

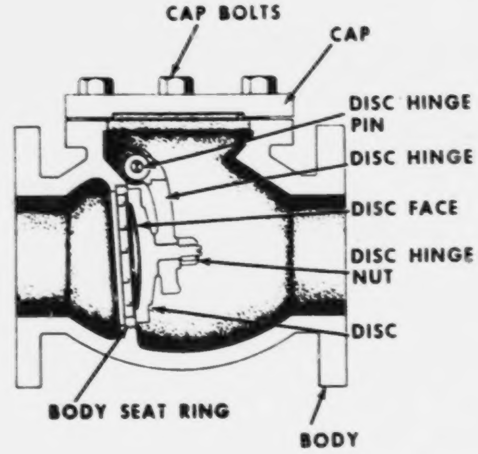

CAP BOLTS
CAP
DISC HINGE PIN
DISC HINGE
DISC FACE
DISC HINGE NUT
DISC
BODY SEAT RING
BODY

Figure I-9d-9. Cross Section of a Swing Check Valve

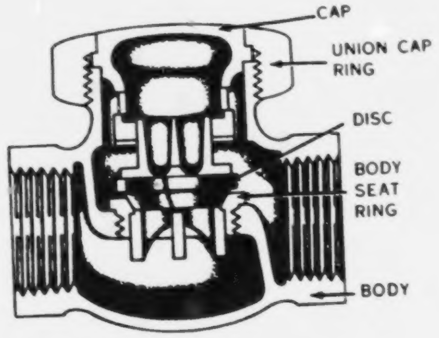

CAP
UNION CAP RING
DISC
BODY SEAT RING
BODY

Figure I-9d-10. Cross Section of a Lift Check Valve

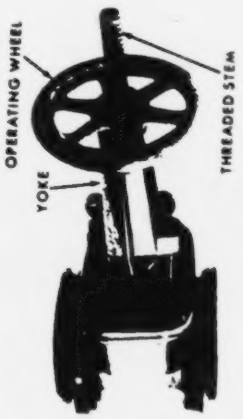

OPERATING WHEEL
THREADED STEM
YOKE

Figure I-9d-11. O S & Y Valve

Summary

Now that we have covered the purpose, types, and components of valves, you can see they are not complicated. You will have the opportunity next to do maintenance on a check valve and a gate valve.

EXERCISE I-9d

INSTRUCTIONS

Use your SW J3ABR56631 000-I-9, to complete the following questions on valves.

1. A gate valve must be either fully ________________ or ______________________.

2. A gate valve ________________ (can, cannot) be used to control the rate of flow.

3. A globe valve _______________ (can, cannot) be used to control the rate of flow.

4. A check valve provides free flow in __________________________ direction only.

5. Name the two basic types of check valves.

   a. ____

   b. ____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instructions, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must complete the progress check under instructor supervision and complete it prior to leaving for the day.

MAINTENANCE OF CHECK VALVES

Check valves are easy to maintain and in most cases can be done while the valve is installed. Normally all that is required is a good cleaning and lubrication of the disc pin on a swing check. Be sure any lubricant used is non-toxic.

Swing Check Valve Repair

The swing check valve is very simple to disassemble for repair. The first step is to place the valve body in a vise if it is out of the line. Grip the valve by the ends with the vise. Be sure the vise has soft jaws or protect the ends with a rag. Next remove the cap. Some valves have bolts, while others screw on. (See figure I-9e-1 and I-9e-2)

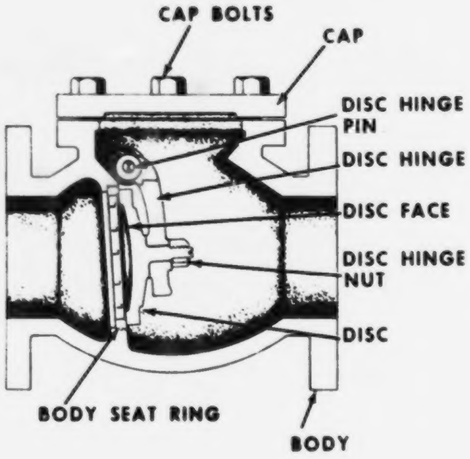


Figure I-9e-1.
Cross Section of a
Swing Check Valve

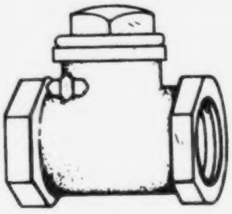


Figure I-9e-2.
Check Valve

Next, remove the hinge pin. Some hinge pins screw in while other slip in and are held in place by plugs. Remove the plugs and slip the pin out or unscrew it. Remove the disc using care not to damage it. Inspect the disc, if metal, for any scratches. If the disc is compositional, it may be removed and replaced with a new one. A metal disc may be smoothed and cleaned using fine emery cloth. Inspect the seat. Small scratches may be smoothed out with fine emery cloth. Clean the hinge pin with fine emery cloth or steel wool. Reassemble in reverse order of disassembly. Lubricate the hinge pin with a non-toxic lubricant.

Lift Check Valve Repair

Like the swing check valve, the lift check valve is easy to repair in the line or out. Remove the cap as you did on the swing check valve. After removing the cap, simply lift the disc, also known as a poppet, from the valve body. Inspect and clean the disc and seat as you did on the swing check valve. The disc and seat can be cleaned and faced by using a lapping compound. Place a small amount of lapping compound on the disc. Place it in the body against the seat. Then rotate the disc back and forth applying a light pressure. Not all valves can be done this way because the disc slips in guide slots which prevent it from rotating. Reassemble in reverse of disassembly.

Summary

Check valves are easy to maintain but normally require very little maintenance. Once the valve is installed there is no way you can tell if it is working unless you disconnect the supply side.

EXERCISE I-9e

PROCEDURES

Complete the following statements by filling in the blanks. You may use the study guide.

1. To disassemble a check valve, remove the ____________________ first.

2. Some swing check hinge pins are _______________ in and others ______________ in.

3. A lift check may be cleaned and scratches removed from seat and disc at the same time by ______________________.

4. Any lubricant used in a valve must be __________________.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review the previous instructions, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

REPACKING GATE VALVES

A very common maintenance problem with valves is leakage at the stem. Many times this leakage problem can be corrected by tightening the packing nut. When this does not stop the leak, then the packing must be replaced.

Types of Packing

Different varieties of valves use different types of packing to prevent leakage at the stem. Some valves use rubber "O" ring packings or flat packings. Some valves, especially large ones use graphite impregnated fiber packing. The packing may be solid flat rings, split flat rings or string type. All packing must be the correct size. The inside diameter must fit the stem and the outside diameter must fit the stuffing box. (See figure I-9f-1) String packing is asbestos string impregnated with oil and graphite. Graphite provides the lubricant with a non-toxic lubricant to achieve the same results.

Exercise I-9f contains the step by step procedures for repacking a gate valve.

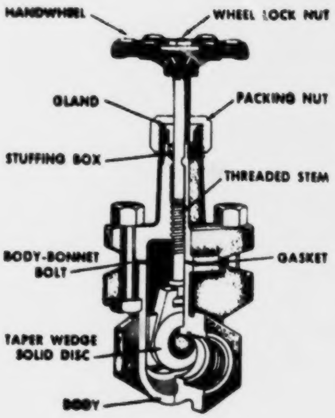


Figure I-9f-1. Gate Valve

SUMMARY

Repacking a valve stem takes very little time and should be accomplished as soon as possible after the leak is detected. This will prolong the life of the valve and prevent a constant cleanup problem.

EXERCISE I-9f

INSTRUCTIONS

Using the gate valve on the pump trainer, remove and replace the valves packing using the step-by-step procedures.

1. Remove the round handle, and place the nut and handle on the workbench.

2. Remove the top packing nut.

NOTE: Now you can see the packing gland.

3. Use a rag in the jaws of a pair of pliers and carefully remove the packing gland.

4. Use either a packing puller or a pointed metal probe, carefully remove the packing from the stuffing box.

   NOTE: DO not nick the valve stem.

5. Clean and polish the valve stem with fine emery cloth or steel wool.

6. Obtain the correct size packing and cut to length.

   a. To determine the correct length, wrap the packing around the stem until it butts together.

   b. Make the cut at a right angle to the length of the packing (this is to insure a water-tight seal) as the ends will lay parallel.

   CAUTION: Never wrap the packing around the stem more than once without cutting it.

7. Insert as many rings of packing as necessary to fill the stuffing box to within 1/16 inch of the top. Always stagger joints in the packing rings.

8. Reinsert the packing gland.

9. Install and tighten the packing nut.

   NOTE: Tighten the packing nut just enough to eliminate the possibility of leaks.

10. Reinstall the handle and retaining nut.

11. Pressurize the valve and check your work. If you have a leak, slowly tighten the packing nut until the leak stops.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instructions, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

ELECTRIC MOTORS

You, as a water or wastewater plant operator, will do minor maintenance of the electric motors in your plant. When you find a motor that needs repairs, report it to the Civil Engineering Service Call Desk. The electric shop or civilian contractors will repair the motors. You will do before operations inspections, operational checks, and after operations inspections. If you are required to service an electric motor, you must follow manufacturer's instructions. It will be your responsibility to do the maintenance on the list that follows.

Operational Checks

Operational checks are divided into three areas. They are preoperational checks, operational checks, and post operational checks.

PREOPERATIONAL CHECKS

1. Keep motors free of dirt and moisture
2. Keep operating area free of articles that may block air flow
3. Check wiring for condition
4. Check for oil leakage from the bearings
5. Check mounting belts for tightness
6. Check to make sure guard is in place and secure
7. Check drive linkage for conditions
8. Lubricate bearings
    a. Check oil in sleeve bearings, replenish if required
    b. Check grease in ball or roller bearing
    c. Fill drip oiler supply

OPERATIONAL CHECKS

Report any of the following defects to the Service Call Desk for correction by the electrical shop:

1. Unusual noises
2. Motor fails to start or come up to normal speed. Sluggish operation
3. Motor or bearings feel or smell hot
4. Continuous or excessive sparking at commutator or brushes; blackened commutator
5. Intermittent sparking at brushes
6. Fine dust under coupling with rubber buffers or pins
7. Smoke, charred insulation, or solder whiskers extending from armature
8. Excessive hum
9. Regular clicking
10. Rapid knocking
11. Brush chatter
12. Vibration

POST OPERATIONAL CHECKS

1. Check mounting bolts for tightness
2. Check wiring to be sure it is secure
3. Insure power is off
4. Check guards for security
5. Check drive linkage for condition

Power Connections

Belts, chains or couplings are used to connect motors to the equipment they drive. The maintenance of these components is part of the plant operators job.

BELT DRIVES. Belt drives in use today are generally of two types; "V" belts and flat belts.

"V" Belts. The "V" type belt is the most common type in use these days. The advantages of a "V" belt are that they are thicker so they are stronger, tension can be adjusted easier and they may be operated at higher speeds. Multi belt drives are more practical with "V" belts. The v provides a three sided gripping surface so the belt grips the pulley stronger.

Flat belts. Flat belts are used, but transmission is poor as the belts tend to get hard, slick spots on them and they begin to slip. They are also difficult to adjust and keep in adjustment. Without an idler pulley it is extremely difficult to prevent them from slipping. Flat belts do work well when used with a heavy fly wheel. The rotation of the fly wheel provides inertia energy. For best results, flat belts are used at low speed.

Belts should be stored in a cool dark place. The belts should also be tagged so that you can find the belt you need.

CHAIN DRIVES. Chain drives are used frequently in the operation of water and wastewater plants. The two types of chain drives used are pintle chains and roller chains.

Pintle Chains. Pintle chains are used for slow speeds. An example of where you will see a pintle chain is in a settling basin. The chain moves skimmer/scraper bars through the water very slowly so as not to disturb whatever has settled in the tank. Pintle chains used in settling basins are usually lubricated by natural grease in the wastewater or are water lubricated.

Roller Chains. Roller chains are high and medium speed chains and will be used to drive another piece of equipment. Lubrication for medium speed chains is usually done by means of a drip type oil feeder while high speed chains will usually be enclosed in an oil tight case for constant lubrication.

COUPLINGS. Couplings are used to connect a drive shaft to a driven shaft. They also permit easy assembly of equipment and motors.

SHEAR PINS. Shear pins may be found in many sewage plant units. These devices prevent damage to equipment in case of sudden overloads.

Maintenance

Maintenance is the life line of all mechanical systems. Periodic inspections reveal minor discrepencies that may become critical at a later date.

INSPECTION. Periodic inspections should be made on all parts and types of drive systems. These inspections should include but not be limited to alignment, wear, and tension. They may be made daily, weekly, monthly, quarterly, etc.

ELECTRIC MOTORS. Listen for unusual noises, look for abnormal sparking and overheating. After operation, check the mounting bolts, wiring grounds, guards and drives.

BELT DRIVES. Look at the edges of the belt for fraying. Look for oil or other foreign material on them.

Adjusting Belt Tension and Alignment. A properly adjusted belt has a slight bow in the slack side when running. When the belt is idle, it has a spring to it when thumped with the hand; an improperly tightened belt feels dead when thumped. If tightening the belt to proper tension does not correct slipping, check for overload, oil on belts, or other possible causes. Never use belt dressing to stop slippage. Rubber droppings near the drive are a sign of improper tension, incorrect alignment, or damaged sheaves.

Cleaning Belts. Keep belts and sheaves free of oil which causes belts to deteriorate. To remove oil, remove belts and clean with a residue free solvent.

Replacing Belts. Replace belts as soon as they become frayed, worn, or cracked. Never replace one belt on a multiple systems (2 or more). Replace the complete set with a set of matched belts. All belts in a matched set are machine checked to insure equal size and tension. Before installing a belt, replace worn or damaged sheaves, then slack off on adjustments. Do not try to force belts onto a sheave. After the belt is installed, adjust the tension then recheck tension after eight hours of operation.

To correct the alignment lay a long straight edge or string across outside faces of pulleys and allow for differences in dimensions from center lines of grooves to the outside of the faces of the pulleys being aligned. Be especially careful in aligning drives with more than one belt on a sheave, since misalignment can cause unequal tension.

CHAIN DRIVES. Some common symptoms of improper chain drive operation and their remedies are as follows:

1. Excessive Noise: Check alignment, proper chain slack and lubrication. Be sure all bolts are tight. If the chain or the sprockets are worn, reverse, or renew if necessary. Frequently, additional chain life can be obtained by turning the chain over.

2. Wear on Chain Sidewalls and Sides of Teeth: Remove the chain and correct the alignment.

3. Chain Climbs Sprockets: Check for poor fit between chain and sprockets, and replace if necessary. Make sure a tightener is installed on the drive chain.

4. Broken Pins and Rollers: Check for chain speed, which may be too high for the pitch. Check for poorly fitting sprockets. Replace them if necessary. Breakage may also be caused by shock loads.

5. Chain Clings to Sprockets: Check for incorrect or worn sprockets, or heavy tacky lubricants. Replace or reverse sprockets, or change to proper lubricant.

6. Chain Whip: Check for centers that are too long or high pulsating loads and correct the problem.

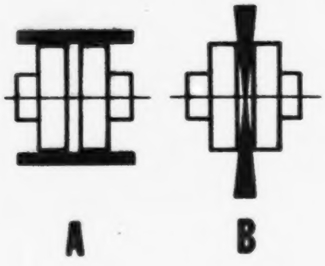
7. Chain Gets Stiff: Check for misalignment, improper lubrication, or excessive overloads. Make the necessary adjustments and corrections.

8. Spare Links: Check to see if spare links are clean oiled and ready for use

9. Guards: Guards should be properly placed and secured.

COUPLINGS. Proper alignment of the coupling essential. If the coupling is not lined up it will cause damage or excessive wear to the coupling itself, the driven machinery, or the driving equipment. Burned out bearings, broken shafts and excessively worn gears are also results of misaligned couplings.

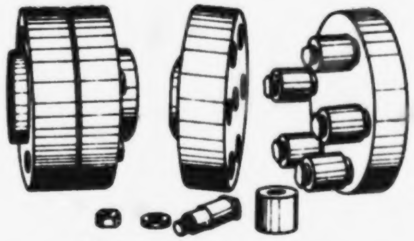
To check the alignment up and down, and left and right as in figure I-9g-1A use a thickness guage or wedge to see if the shafts are at an angle as shown in figure I-9g-1B. The shafts are straight when the gap in the coupling is the same all the way around. It is a good policy to use the same gauge all the way around, this avoids error due to a worn guage. To operate properly the coupling must be no more than 0.005 of an inch out of line.



CHG 134

Figure I-9g-1. Alignment of Couplings

Flexible couplings (figure I-gh-2) permit the easy assembly of equipment. They are not designed to make up for poor alignment. The same procedures and care just discussed are used to align flexible couplings. Coupling alignment should be checked when the bearing or motor temperature is high.



ALLIS-CHALMERS FLEXIBLE COUPLING

Figure I-9g-2. Flexible and High Speed Coupling

SHEAR PINS. It is important that if a shear pin breaks it should be replaced with one of the same strength. A bolt or nail should never be used in place of a shear pin. When the pin breaks, determine the cause and remedy the problem before replacing the pin. To replace a broken shear pin, remove the pin. Lubricate the parts if necessary and operate the motor for a short time with the shear pin removed to smooth out any corroded or rough spots on the shaft and other parts. Grease the shearing pin surfaces with WB or QE 30 grease. Then replace with a new pin.

More information can be found in AFR 91-26, Chapter 4, Section B.

EXERCISE I-9g

INSTRUCTIONS

Use SW J3ABR56631 000-I-9 to complete the following.

1. Inspect an operating electric motor.

   a. Is there any unusual noise in the motor? Yes - No

   b. Does the shaft wobble or shake? Yes - No

   c. Is the motor securely mounted? Yes - No

   d. Is the motor overheating? Yes - No

   e. Are there any sparks coming out of the motor? Yes - No

2. Inspect after operation.

   a. Is the motor dirty with mud, grease, rag lint, or leaves and grass? Yes - No

   b. Does the motor have an oiling hole or grease zerk? Yes - No

   c. Are the electrical wires in good condition? Yes - No

   d. Are there any exposed wires? Yes - No

3. What is the reason for performing daily inspections? ____________________

   ____

4. List three possible maintenance problems concerning electric motors.

   a. ____

   b. ____

   c. ____

5. Belts and chains should be checked for ______________ and ______________.

6. Name four conditions that you would observe during a daily inspection of a chain driven piece of equipment.

   a. ____

   b. ____

   c. ____

   d. ____

7. What is the purpose of a sheer pin?

   ____

   ____

8. Inspect the coupling between the motor and the Peerless Fluidyne pump.

   a. What absorbs the shock of starting and pumping vibrations?

   ____

   ____

   b. What wrench is needed to loosen this coupling from the shaft?

   ____

PROGRESS CHECK

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CHEMICAL FEEDERS

Water treatment usually includes the addition of various chemicals at a controlled rate, which is proportional to the volume of the water being treated. The three types of chemical feeders that can be used to accomplish this are: Solution feeders, Dry feeders, and Gas feeders. The state of the chemical being added to the water determines the type of feeder needed.

Solution Feeders

Solution feeders are used for dispensing a chemical which is in the liquid or dissolved state. The rate at which the chemical is added may be controlled manually or automatically by the quantity of flow. These feeders are positive displacement piston or diaphragm pumps. They have a solid metal or plastic piston or a rubber diaphragm that pulls the solution into the pump and pushes it out using a reciprocating or back and forth motion.

A hypochlorinator is a common example of the chemical solution feeder. Its principle function is to add chlorine, in the form of calcium or sodium hypochlorite solution, to the water supply. This type unit may be used to add other chemicals also. Hypochlorinators are usually modified positive displacement, piston or diaphragm pumps, however, hydraulic displacement hypochlorinators are also used. Figure I-9h-1 shows a typical hypochlorinator setup.

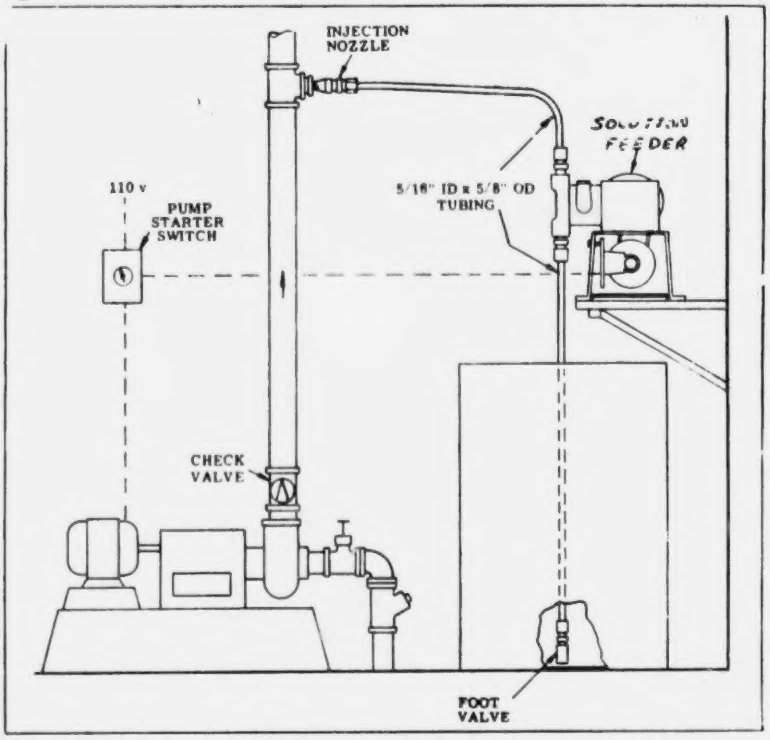


Figure I-9h-1. Solution Feeder Used With a Well

Dry Feeders

Dry feeders are used for dispensing a chemical or other fine material in the solid form. Like solution feeders the rate at which the chemical is added may be controlled manually or automatically by the rate of flow. There are two types of dry chemical feeders; gravimetric or volumetric. Volumetric feeders dispense a preset volume of chemical and will deliver as little as three to four ounces per hour to treat supplies of 200,000 gallons or more daily. Gravimetric feeders displace a definite weight of chemical and are usually used for systems of 5 million gallons a day or more. Chemicals which are commonly fed in the dry condition include lime, soda ash, and fluoride compounds. Figure I-9h-2 shows a gravimetric dry chemical feeder.

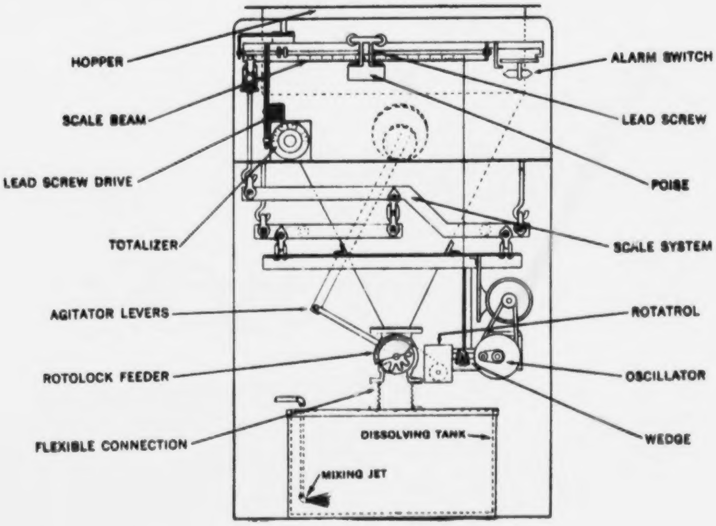


Figure I-9h-2. Gravimetric Dry Chemical Feeder

Gas Feeders

The gas feeders you'll be operating while in the Air Force will usually be gas chlorinators. There are two types of gas chlorinators; direct feed and vacuum feed.

DIRECT FEED CHLORINATORS. Direct feed chlorinators feed chlorine gas directly into the water being treated. They are used chiefly as emergency equipment or on small installations. They cannot be used where the pressure of the water system is greater than 20 psi. Since the chlorine is under pressure as a gas at all times this type of chlorinator is highly susceptible to leaks. Water reacts with clorine to form a highly corrosive acid, so any leakage results in extensive corrosion and danger.

VACUUM FEED CHLORINATORS. Vacuum feed chlorinators feed chlorine gas into a water supply by means of a chlorine solution. The solution is formed by drawing the gas into a jet stream of water at the low pressure point of an ejector mechanism. Because the chlorine gas is kept under a partial vacuum this type chlorinator is less susceptible to leaks than is the direct feed chlorinator. Figure I-9h-3 shows a typical vacuum feed chlorinator connected to a chlorine gas cylinder. The chlorine solution is feed into the line carrying the water.

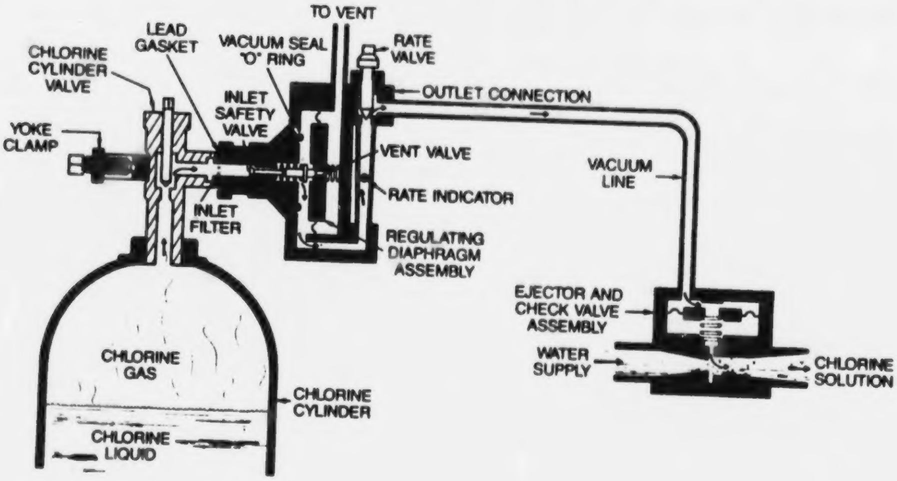

TO VENT
LEAD GASKET
VACUUM SEAL "O" RING
RATE VALVE
CHLORINE CYLINDER VALVE
OUTLET CONNECTION
INLET SAFETY VALVE
YOKE CLAMP
VENT VALVE
VACUUM LINE
RATE INDICATOR
INLET FILTER
REGULATING DIAPHRAGM ASSEMBLY
EJECTOR AND CHECK VALVE ASSEMBLY
WATER SUPPLY
CHLORINE SOLUTION
CHLORINE GAS
CHLORINE CYLINDER
CHLORINE LIQUID

Figure I-9h-3. Vacuum Feed Chlorinator

EXERCISE I-9h

INSTRUCTIONS

Use SW J3ABR56631 000-I-9 to complete the following.

1. A hypochlorinator is an example of which type of chemical feeder?

____

2. What type of pump is commonly used for solution feeders? ____________________

____

3. What are the two types of dry chemical feeders? ____________________

4. Which type of dry feeder diplaces a definite weight of chemical?

____

5. What are the two types of gas chlorinators? ____________________

6. Which type of gas chlorinator produces the most leaks? ____________________

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and is controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

CHEMICAL FEEDER MAINTENANCE

INFORMATION

A comprehensive maintenance program is essential to the long life of chemical feeders. The following information is designed to give you a general overview of maintenance procedures for chemical feeders. For specific maintenance procedures you should refer to the manufacturers' manual that came with the feeder.

Safety Precautions and Tool Selection

As was discussed in the earlier unit on safety all chemicals should be treated as if they are dangerous. For this reason it is important that you take the necessary precautions when performing maintenance on chemical feeders. Solution feeders need to be purged of the chemical in them before working on them. Gas feeders are required to be in rooms with forced air ventilation in case of gas leaks. Selecting the proper tool to use when performing maintenance will prevent unnecessary damage to the feeder. Manufacturers' specifications may help with tool slection. The only tool required for plastic parts, however, is your hand. Plastic parts need only be hand tightened, because wrenches or other tools could easily crack the plastic parts.

Preventive Maintenance

SOLUTION FEEDERS

a. Each Day the equipment is operated:

(1) Check operation. Inspect sight-feed indicators to insure that solution is being fed.

(2) See that automatic controls start and stop properly.

(3) Make sure there is enough prepared solution.

(4) Check for leaks in piping joints and packing glands.

b. Weekly

Clean Feeder: Remove and clean glass and plastic parts of sight-feed indicator. Remove white coating caused by hard water in the hypochlorite solution, by soaking in a five percent solution of muriatic (hydrochloric) acid.

c. Monthly

Clean and flush solution tank.

(1) Clean suction strainer and hose.

(2) Disassemble, inspect and clean solution diaphragm chambers and check valves.

(3) Clean screens and strainers on water-operated feeders.

(4) Exercise all shut-off valves and length of stroke controls.

d. Annually

Overhaul feeders

(1) Replace worn parts and packing.

(2) Touch up and paint all metal parts.

DRY FEEDERS

a. Each Day the equipment is operated.

Clean and Check. Clean feeder, feeder mechanism and surroundings. See that scale is sensitive to small weight changes. When the feeder is completly empty, determine its tare weight or see that the scale shows zero weight. Look for oil drips and wiring defects. Observe general performance of feeder and changing tare weights of the scale. Probe solution tank for sediment or undissolved chemical. Clean the tank and improve dissolving conditions if necessary. If the feeder is out of service see that the hopper and feed mechanism are empty and that condensation is not causing corrosion or deterioration.

b. Weekly

Inspect for loose bolts and defective parts. Carefully wipe clean all parts of feeder and make necessary repairs.

c. Quarterly

Service drive mechanism and moving parts according to manufacturers instructions.

d. Annually

Overhaul Feeder and Scale: Disassemble feeder and clean and inspect all parts for wear or deterioration. Clean and paint feeder inside and out where necessary. Make required repairs and properly lubricate all mechanical parts. Service motors and drive mechanisms.

GAS FEEDERS

a. Each Day the equipment is operated.

(1) Inspect for leaks. Examine chlorinator and all piping for chlorine or water leaks. All chlorine leaks are serious because they increase rapidly in size and cause extensive corrosion and damage. Red discoloration means scale. To locate chlorine leaks, hold the mouth of an open ammonia-water bottle near all joints, valves, and along pipes; any white fumes from the bottle are ammonium chloride and indicate a chlorine gas leak. Keep the ammonia-water bottle tightly closed when not in use to prevent a loss of strength.

(2) Operate Chlorine Valves. Open and close all chlorine valves to keep threads on the valve stems from becoming set in one position. Do not use force to close a valve. Check stuffing boxes. Repair or replace faulty valves at once.

(3) Check Gas System. Check to see that all pipes and parts that carry chlorine gas are operating properly. See that metering devices, pressure reducing and shut-off valves function properly. Disassemble and clean where necessary, determining the cause of the fault. At first sign of weakening, replace any faulty parts.

(4) Check Vacuum Relief. Make sure that the entire assembly operates properly and that the relief hose is not plugged. Insects, such as mud daubers, may plug such lines by building nests in them.

b. Weekly:

Throughly clean chlorinator cabinet, glass parts, floats, metering devices, and other parts in which dirt might interfere with the operation or make equipment unsightly. Clean and cover bare metal that might corrode, with a good film of petrolatum or similar protective compound.

c. Monthly:

Check water system. Clean the water strainers and check pressure-reducing valve for proper operation. See that float valves are properly controlling water levels and that there is little or no leakage. See that water flowing to waste is not excessive and that water levels are kept at their proper elevations. See that ejectors have the right capacities. If they do not, remove and clean with muriatic acid.

d. Quarterly:

Disassemble or Operate Hard Rubber Threads, Valves, and Parts. Hard rubber threads or parts on a chlorinator freeze or stick when not operated for long periods, this will cause them to break when they are disassembled. To keep the threads from freezing, operate all parts needed to keep chlorinator in service. Do this more often if necessary. Before you reassemble such parts, cover them with graphite.

e. Annually:

(1) Overhaul. Disassemble and clean all chlorinator parts thoroughly. Paint chlorinator cabinet inside and out with rust-resistant paint. Carefully examine each chlorinator part. Reassemble and check for proper operation.

(a) The only safe liquids you can use to clean chlorine lines are wood alcohol and trichlorethylene. After cleaning, allow cleaning solution to evaporate to dry the lines. Ethyl alcohol or ether must NOT be used as they react with chlorine to form a solid waxy substance which is very difficult to remove. Water reacts with chlorine to form a highly corrosive acid.

(b) Oil or grease react with chlorine to form a bulky, frothy substance. Therefore, they should NOT be used as lubricants at points where they may come in contact with chlorine.

(c) Condensation that forms on chlorine cylinder outside walls may corrode scales and other equipment around the cylinder. Guard against such damage by insuring that there is sufficient ventilation around the equipment to keep it dry. An electric fan may suffice. Do not apply direct heat to dry the cylinder.

(d) It is dangerous to attempt to increase the rate of gas withdrawal by heating chlorine cylinders or containers above the normal room temperature with hot water baths or other means. Inspect regularly to see that chlorine cylinders are not exposed to direct sun heat or near steam or hot water lines or other sources of heat.

(e) Use a new lead gasket each time you connect a valve or tube and when you replace empty chlorine cylinders. Use only ONE lead gasket.

All the maintenance procedures that have been listed above are general procedures for all types of feeders. For more specific procedures you should refer to AFR 91-26 or the manufacturers' specifications.

CHEMICAL FEEDER DISASSEMBLY/INSPECTION/ AND REASSEMBLY

Chemical Feeder disassembly, inspection and reassembly. Read and become familiar with the instruction procedures on Chemical feeders. Upon completion of this area of instruction, you will be given a progress check along with the units to accomplish the inspection procedures.

Chemical Solution Feeder

DISASSEMBLE UNIT

1. Remove suction and discharge tubing
2. Remove poppet valves
3. Remove four (4) screws and pump head
4. Remove flexible diaphragm
5. Remove rubber boot

210

INSPECT COMPONENTS

6. Inspect for cracks and tears on rubber boots and flexible diaphragm.

7. Inspect for cracks on plastic pump head.

8. Check the O-ring for worn areas and cracks.

9. Insure chemical passage channels are clear.

10. Insure poppet valves are free from scale or chemical buildup - insure valves seat properly.

11. Check to insure chemical feeder lines are unobstructed.

REASSEMBLE UNIT

12. Before installing feeder parts, turn feeder control knob to #10 feed rate.

13. Install rubber boot on pump shank.

14. Install rubber diaphragm.

15. Install plastic pump head with four (4) screws.

16. Install suction and discharge tubing and poppet valves.

17. Prime the chemical feeder.

18. Operate the chemical feeder and pump a liquid through the feeder lines.

19. Adjust control knob to #6 feed rate.

Dry Chemical Feeder

Disassemble Unit

Inspect Components

Reassemble Unit

Disassemble Unit

1. Remove upper and lower half unions
2. Remove back screws
3. Remove back panel
4. Remove diaphragm guide plate assembly
5. Disassemble diaphragm guide plate assembly
    a. unscrew top plate
    b. remove diaphragm
6. Remove flowmeter
    a. remove top fitting
    b. remove glass window
    c. remove bottom fitting
    d. remove bottom seal plug

Inspect Components

1. Check half unions for cracks, cross threading.
2. Check back and front body assemblies for cracks, corrosion.
3. Check diaphragm guide plates and diaphragm for cracks, tears, corrosion.
4. Check flow meter for dirt, obstructions.
5. Check seal plug and O-rings for cracks, leaks.

Reassemble Unit

1. Install flowmeter
2. Install diaphragm and guide plate assembly
3. Install front and back panels.
4. Install upper and lower half unions.

EXERCISE I-9i

PART 1

INSTRUCTIONS

NOTE: These procedures apply (in general) to all chemical feeders.

1. Disconnect the power from the source.

   CAUTION: Do not perform maintenance on any equipment unless the power source is disconnected.

2. Disconnect the solution lines.

   CAUTION: Do not let the solution come in contact with the skin.

3. Refer to the mnufacturer's instructions for further disassembly procedures. (94 Series Solution Metering Pump instruction book.)

PART 2

NOTE: Use the 94 Series Solution Metering Pump instruction book to answer the following questions.

4. What type of tool is used to loosen and tighten four head bolts on solution feeder?

   ____

5. What must you check the diaphragm and boot for after disassembling?

   ____

   ____

6. What is the indicator knob set on before reassembling? ______________

   ____

7. All plastic parts must be ______________ tight.

8. If solution feeder pump doesn't pump solution, there are two things to check for, what are they?

   a. ______________________________

   b. ______________________________

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

Water meters and flow measuring devices, measure volume and rate of flow of water. They may work on one of three principles - volume displacement, velocity or pressure differential.

Types of Measuring Devices

There are various types of measuring devices used in this career field. Three of the more common types are weirs, water meters, and parshall flumes.

WEIRS. Weirs are used to measure flow in open channels or streams. A weir consists of a bulkhead or dam across the channel or stream and a sharp level crest or specially shaped notch mounted on the crest. The volume or flow over the weir varies with length of the crest or shape and size of the notch and with the elevation of the water surface above the crest or the bottom of the notch. Because both the head and the cross-sectional area of flow over the weir vary with the flow, it is a head area measuring device. Weirs are easily built and give fairly accurate measurement if properly installed. The most common type of weirs are the rectangular and V-notch weir. Rectangular weirs are used for flows over 150 to 200 gpm and the crest should be a sharp beveled metal plate. The V-notch weir is preferred for flows less than 1,000 gpm and is particularly suitable for very low flows.

WATER METERS. Water meters are devices that are installed in a pipe under pressure for measuring and registering the quantity of water passing through the pipe. The four main types of water meters are, positive displacement, turbine or velocity, compound, and venturi meters.

Positive Displacement. The positive displacement type meters use an "oscillating piston" or a "nutating disc" measuring device that drives a register to "count" the number of times the measuring chamber is filled and emptied. Positive displacement meters are often used when the flow in the line is consistently low. These meters should be accurate within plus or minus 2% with changing flow rates. At high flow rates this type meter restricts the flow of water. Figure I-9j-1 shows a nutating disc water meter.

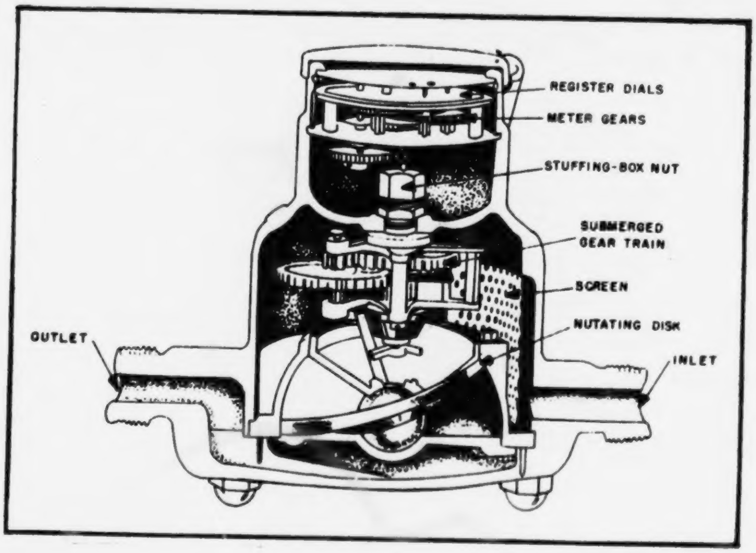


Figure I-9j-1. Nutating-Disc Water Meter

Current Velocity. The current meter or turbine type meter uses a propeller device that depends on the velocity of the water to turn the recording mechanism. These meters do not restrict the flow as much as high flow rates. Their chief disadvantage is that they will not accurately measure low flow rates (see figure I-9j-2).

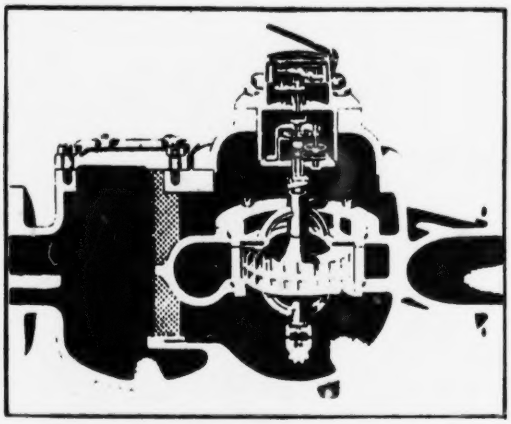


Figure I-9j-2. Current or Turbine Type Meter

Compound. The compound meter is a combination of a positive displacement and a velocity meter. At low flow, all the water is forced through the positive displacement meter. When the velocity increases, a weighted check valve opens and allows most of the water to pass through the velocity meter. Thus, the advantages of both meters are utilized (see figure I-9j-3).

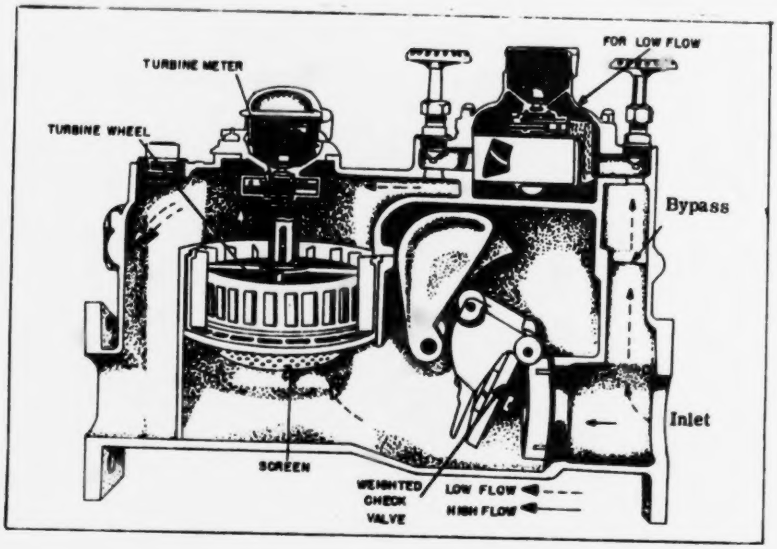

TURBINE METER
TURBINE WHEEL
FOR LOW FLOW
Bypass
Inlet
SCREEN
WEIGHTED CHECK VALVE
LOW FLOW
HIGH FLOW

Figure I-9j-3. Compound Meter

Venturi Tube and Orifice Meter. The venturi tube or orifice meter uses the principle of pressure differential to measure flow. The pressure differential through a venture or an orifice in a pipe indicates the rate of flow. You read the volume of water from recorder charts (see figure I-9j-4).

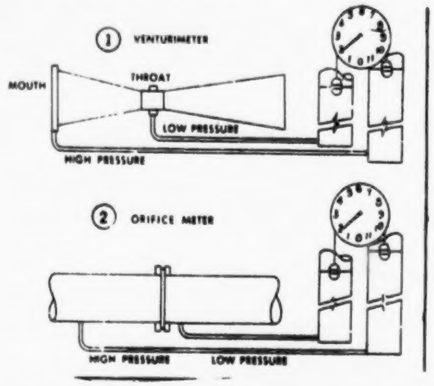

① VENTURIMETER
MOUTH
THROAT
LOW PRESSURE
HIGH PRESSURE
② ORIFICE METER
HIGH PRESSURE
LOW PRESSURE

Figure I-9j-4. Venturi Meter and Orifice Meter

The venturi meter has no moving parts in the stream and it causes only a slight reduction to the flow. It is not accurate at low flow rates. The orifice meter causes considerable restriction to the flow but is accurate at low flow rates.

The venturi meter is more accurate than other flow measuring devices. They also cost more than other measuring units and they must always be operated with the pipe full. They are not often used in wastewater plants.

PARSHALL FLUME. The Parshall flume is often used to measure wastewater flow because it is simple and has no problems with sand or suspended solids. The operator can build a Parshall flume like the one in Figure I-9j-5, or buy one already built. The basic parts of a flume are the converging section, a constricted section or "throat", a diverging section, a float or gauge.

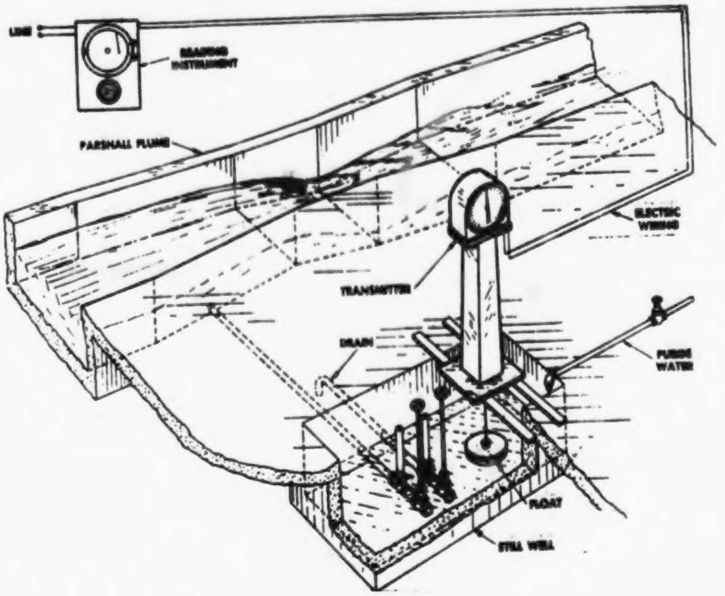

LINE
READING INSTRUMENT
PARSHALL FLUME
ELECTRIC WIRING
TRANSMITTER
DRAIN
PURGE WATER
FLOAT
STILL WELL

Figure I-9j-5. Parshall Flume with Metering Device

Still Well. A still well is a small well located on the side of the Parshall flume and connected to it by a pipe. The connecting pipe should have a valve. The valve is to be wide open at all times except for cleaning and repairs. The pipe should be large enough for easy cleaning and should be level or should slope toward the flume. A float well drain is usually provided to make cleaning the float well easier. This allows the water in the float well to stay at the same level as the water in the flume. The float well or stilling well should be located upstream from the throat. It should be 2/3 of the way up the side of the coverging section. The still well gauge is often connected to a device which measures the "head" in the flume and records the flow in gallons per minute, or gallons per day. The flow may also be checked by placing a measuring stick in the flume at the same place as the float well and reading the head in inches. Once the head is measured, it can be used to find the flow in million gallons per day.

A flow of clear water should be sent into the still well (float well) to keep a flow from the well to the flume. This will be of great help in preventing accumulation of solids on the float, walls of the float well and in the connecting pipe. If drinking water is the source, the supply pipe should stop at least two inches above the top wall of the gauge well, thereby preventing pollution by cross connection.

RECORDERS. Recorders are devices that translate the action of the water flow on the primary element in terms of water quantity or rate of flow. These devices are circular clock driven charts or strip charts where the flow rate is reflected by the movement of a pen upon the chart. The pen traces a continuous ink line on the round or strip chart which is ruled so that a direct reading can be made of the volume of flow. The chart is marked to represent the hours in a day. Recorders may be used with an type of measuring device.

Reading Meters/Recorders

Water is measured in terms of flow rate or total volume passing in a unit of time. When reading a meter or a recorder, the operator should first determine whether it is measuring the water volume in cubic feet or in gallons. Two general types meter dials are the straight reading type and the circular reading type. The straight reading dial may be read in the same way as the mileage on an automobiles' odometer. When the meter register has one or more fixed zeros be sure to read these fixed zeros in addition to the other numerals. In the circular reading dial when a hand is on any scale in between two numbers, the lower number is read. If the hand seems exactly on any figure, check the hand on the next lower scale. If the hand has passed the zero, read the figure on which the questionable hand lies, if the lower scale has not yet passed the zero read the next lower figure.

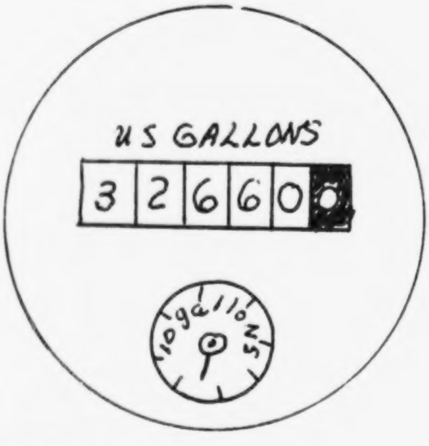


Figure I-9j-6
Straight-Reading
Meter Dial

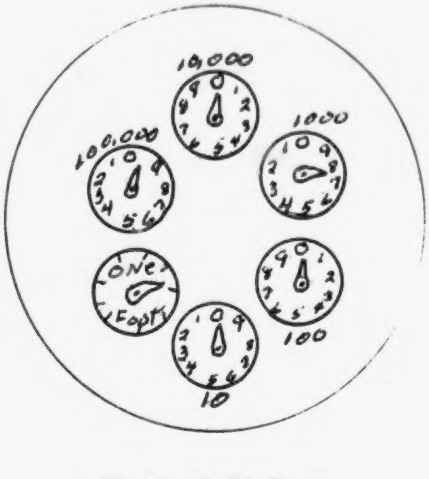


Figure I-9j-7
Circular-Reading
Meter Dial

EXERCISE I-9j

INSTRUCTIONS

Using SW J3ABR56631 000-I-9 answer the following questions.

1. List the three most common types of measuring devices.

    a. ______________________________

    b. ______________________________

    c. ______________________________

2. List the four types of water meters.

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

3. Positive displacement meters use an __________________ or a ___________________ to drive the register or totalizer.

4. What is disadvantage of a current velocity or turbine meter?

5. What is the principle of operation in a venturi or orifice meter?

    ____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

Servicing Meters/Recorders

Repair and maintenance of the different meters are very similar. The common failures are due to swollen discs, scale clogged chambers, worn measuring discs and chambers, or corrosion in the meter. A water meter should operate 5 to 10 years without trouble. A meter that loses its accuracy in a short time can usually be corrected by being cleaned and having the clearances rechecked. Hot water will swell the hard rubber disc and stop the meter.

Cleaning must remove rust, scale and any organic material. You can remove scale and corrosion by a brief application of hydrochloric (muriatic) acid diluted to 5%. Organic matter requires detergent solvents for removal.

You can watch the action of a water meter by observing the gallon indicator on the register as water flows through the meter. Use a flow rate of about 5 gallons per minute for a meter up to 1 1/2 inches. If you see no movements, remove the register and watch the drive gear for movement. If the drive gear does turn, the register is faulty or the drive gears are out of mesh.

You can check a meter for accuracy by placing it in series with a meter known to be accurate. This method is accurate enough for meters used for water treatment monitoring. For very accurate measurement, check the meter by flowing a measured volume of water through it (see Figure I-9k-1).

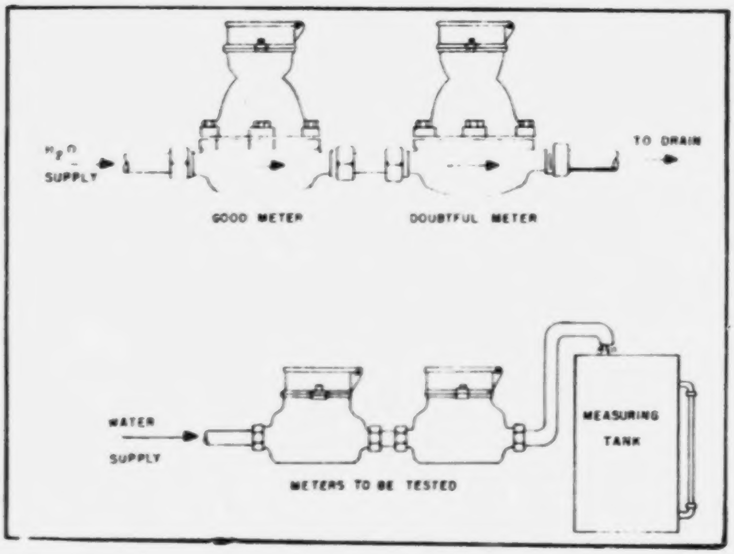


Figure I-9k-1. Testing Water Meters

Daily servicing of records includes:

1. Changing the charts (Round charts)
2. Aligning the chart with the correct time
3. Checking the ink pen for ink supply

You must be careful not to damage the pen when you change charts on the recorder. Lift the pen gently when you remove a chart. If you start a new chart at 8 o'clock in the morning, be sure that you turn the chart so that the 8 o'clock line will be directly under the pen. Be careful not to drop the pen when you replace it on the chart. When you add ink to the pen, be careful to put in only the amount required. Too much ink in the pen will flood it and ruin the chart.

Be sure to mark the chart with the starting date, time and the finish date and time. If the chart has a spring drive, wind the spring, but do not wind it so tight that the mechanism will be damaged.

You should perform periodic maintenance on recorders according to manufacturer's specifications. Maintenance includes checking pen travel, checking calibration, cleaning all parts, and lubricating all moving parts.

Disassembly/Reassembly Procedures

Read and become familiar with the instruction procedures on disassembly and reassembly of a water meter. Upon completion of this area of instruction you will be given a progress check concerning inspection of a water meter.

METERS

1. Disassemble and reassemble a water meter.
   a. Set the Hersey meter on the workbench.
   b. Remove the large flange bolts.
   c. Lift the top body of and lay it on its side.
   d. You can now see the wobble plate and the small drive pins in the center plate in the bottom section of the meter.
   e. Notice the filter screen at the inlet port.
   f. Now look at the bottom of the top section. Notice the spinner. Turn the spinner with your finger and watch the dial of the meter. What happens?
   g. Can you determine how the meter registers the amount of water flowing through the meter?
   h. Carefully replace the top section on the bottom section, install the flange nuts and bolts. Tighten the nuts fingertight only, as the meter will be taken apart again very shortly.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

BACKFLOW PREVENTION

Public health standards require that all parts of a water supply system be free from sanitary defects and health hazards. Any physical connection between a supply of good quality and an unsafe supply will not be permitted. This includes any connections between a potable supply and a sanitary or storm sewage system. You must also be wary of manholes, pumps, valve pits, or any other location that will allow unsafe or contaminated water to enter the potable water supply.

Backflow

Backflow is the flow of water or other liquid mixtures or substances into distributing pipes or a potable supply of water from one or more sources, other than the intended source.

CAUSES. Backflow conditions frequently occur because of carelessness of the user. Other causes of backflow are improper plumbing design and modifications in the plumbing system.

TYPES. There are two types of backflow which can occur in a water system; backsiphonage and backpressure.

Backsiphonage. Backsiphonage is reversal of the normal flow in a system. It is caused by negative pressure in the supply piping. This can be illustrated by covering the procedures for winterizing water lines. After turning off the water to a building, you open both the high and low faucets in the building to drain the system. If you now put your finger in the opening of the higher spout, you feel a vacuum as the system drains. This negative pressure.

Here is an example of how backsiphonage can and does occur:

A pump (such as a fire engine) is connected to a water main near a building. The suction at that point lowers the pressure and water in the system on both sides of the pump would be pulled to that point. Some water would be pulled back even if all the outlets were closed. If an outlet were open all water in that part of the system would be siphoned back.

Backpressure. Backpressure is a positive pressure placed on any downstream component of a system relative to any upstream component. A good example of how backpressure could occur involves a boiler system and the feedline to the boiler. If the boiler operates at 20 psi, everything is fine as long as the pressure in the feedline stays above 20 psi. However, if the feedline pressure drops below the boiler pressure, then the contaminated water in the boiler will flow into the supply line and possibly into the water main.

Cross Connection

The three causes of backflow mentioned earlier all result in something known as a cross connection. A cross connection is any hookup or piping arrangement that allows a path of flow between a potable water supply and another water source of questionable quality.

Types of Cross Connections

In order to identify, correct or provide protection from cross connections, it is important for you to understand the types of piping arrangements you might encounter. There are two types of cross connections. They are the direct and indirect type connections.

DIRECT. A direct cross connection occurs when a potable water line is connected to a line carrying a non-potable liquid. The example used to illustrate backpressure is also an example of a direct type cross connections.

INDIRECT. Indirect cross connections are made thousands of times a day. If a hose is connected to a potable supply and the other end is submerged in a container, you have an indirect cross connection and the possibility for backflow. If this hose were connected to the faucet that was left open in the example with the fire pump you can easily see how backsiphonage could result in a potential hazard to the consumer.

Hazards

Approved backflow devices are used to prevent and combat cross connections. The type to use is based on the degree of hazards. These hazards are divided into three classes. They are determined by the director of base medical services.

CLASS I, LOW DEGREE OF HAZARD. The backflow of a Class I substance into the potable water supply would cause a minor change in water quality, such as taste, odor, or color. The foreign substance must be non toxic and non bacterial, with no significant health effect.

CLASS II, MODERATE DEGREE OF HAZARD. The backflow of a Class II substance into the potable water supply would significantly change the water quality. The foreign substance must be non-toxic to humans.

CLASS III, HIGH DEGREE OF HAZARD. The backflow of a Class III substance into the potable water supply could cause illness or death if consumed by humans. The foreign substance may be toxic to humans either from a chemical, bacteriological or radiological standpoint.

Types of Backflow Preventors

In this section, we will discuss five methods of preventing backflow. One of these methods is physical while the others are mechanical.

AIR GAP. An air gap is a physical separation between the end of the supply and the receiving vessel. It is the best method to prevent backflow and may be used on any class of hazard.

VACUUM BREAKERS. There are two types of vacuum breakers. They are atomspheric and pressure types. Vacuum breakers cannot be used if backpressure may occur.

Atmospheric Type. The atmospheric type vacuum breaker is simply a body which houses a poppet that serves as a check valve in two directions. It is used on a Class I hazard.

Pressure Type. The pressure vaccum breaker differs from the atmospheric type in that the poppet is separated into two spring loaded check valves. It is used on a Class I hazard.

Double Check Valve. A double check valve is composed of two spring loaded check valves, one behind the other. The theory being that both valves won't leak at the same time. It is used on Class I and II hazards.

Reduced Pressure Principle Device. This is commonly referred to as a RP device. It consists of two spring loaded check valves with a relief valve between them. They may be used on any class of hazard.

SUMMARY

Your job is to furnish a good quality of drinking water for base personnel. In order to accomplish this, you must insure that contamination is not voiding all your effort. Backflow devices are receiving continuing emphasis both in the Air Force and civilian communities. Be aware of potential and direct cross connections.

EXERCISE I-91

INSTRUCTIONS

Use SW J3ABR56631 000-9 to complete the following statements.

1. What degree of hazard is caused by a substance that creates a minor change in the water quality? ____________________

____

____

2. A cross connection that would cause significant change in the potable water quality would be given what classification? ____________________

____

3. What classification would be given to a cross connection that would cause people to become ill or die? ____________________

____

4. Which type of backflow preventer can be used only on Class I substances not subjected to continuous pressure? ____________________

5. Which type of backflow preventer can be used in a continuous pressure system to prevent back-siphonage of Class I substances only? ____________________

____

6. Which type of backflow preventer can be used to protect the potable water system from Class I and II substances but not Class III substances? ____________________

7. Which type of backflow preventer should be used in a direct connection-type system to protect the potable water supply from a Class III substance? ____________________

____

8. Which type(s) of backflow prevention devices can be used to protect the potable water system from Class III substances? ____________________

9. How does an air gap protect the potable water system from backflow? ____________________

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instructions, do so. The progress check is prepared as a separate publication and controlled by your instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

OPERATION AND MAINTENANCE OF BACKFLOW PREVENTERS

We have defined causes and types of cross connections, classes of hazards, and listed the type of backflow preventers. In this section you will learn about the operation and maintenance of these devices.

Operation of Backflow Preventers

In this lesson we will cover the five types of backflow preventers and their operation.

AIR GAP. An air gap is a physical separation of the potable and nonpotable system by an air space (figure I-9m-1). The vertical space between the supply line and the floodlevel rim must be at least two times the inside diameter of the supply pipe. It cannot be less than one inch and need not be more than 12 inches. This means that, if the supply pipe is two inches in diameter, then the air gap must be at least four inches wide. An air gap is used on an open or nonpressure receiving vessel. It can be used on all three classes of substances.

NOTE: This is the only positive method of backflow prevention.

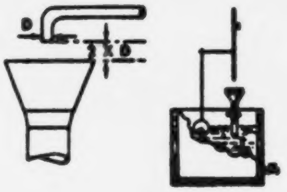


Figure I-9m-1. An Air Gap

ATMOSPHERIC-TYPE VACUUM BREAKER. This type of breaker is a device to prevent back-siphonage of Class I substances into a potable water supply. It has a moving disc floating in the body which, during flow, stops water from spilling from the device (figure I-9m-2). When the flow stops, the disc float drops down to provide a vent to the atmosphere. This prevents a vacuum from occurring on the discharge line by allowing air to enter the line. This device must be installed on the discharge side of the last control valve and at least 6 inches above the highest outlet. It cannot be used under continuous pressure for more than 12 hours or be subjected to back-pressure. Should be same size as system piping.

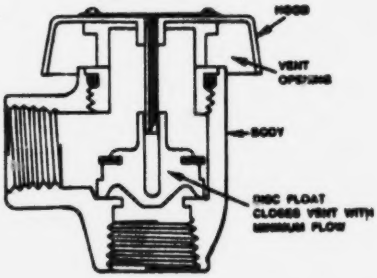


Figure I-9m-2. An Atmospheric-Type Vacuum Breaker

PRESSURE-TYPE VACUUM BREAKER. This device prevents back-siphonage of Class I substances into a potable water supply. It may be used under continuous pressure, but must not be subjected to back-pressure. This device has a moving, spring-loaded disc float and check valve in the body (figure I-9m-3). A gate valve is on both the inlet and the outlet of the body. The body also has test cocks on it. When the supply line pressure drops to 1 psi or below, the spring-loaded disc float opens the atmospheric vent. At the same time, the spring-loaded check valve closes the inlet. This keeps a vacuum from occurring on the discharge line; thus there is a no back-siphonage.

During the normal operation of the device, the flow of water through the device pushes open the check valve. The flow also lifts the disc float, which closes the atmospheric vent, thus preventing leakage. This device must be installed above the overflow level of the system being supplied.

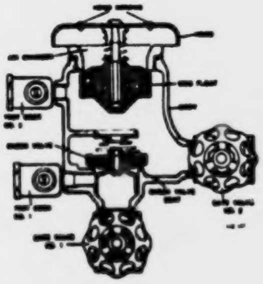


Figure I-9m-3. A Pressure-Type Vacuum Breaker

DOUBLE CHECK VALVE. The double check valve (figure I-9m-4) is used in direct connection-type systems to prevent the backflow of Class I and II substances into the potable water supply. It can be used in continuous pressure systems subject to back-pressure or back-siphonage. This device has two independently operating, spring-loaded check valves in the body. There is a gate valve installed before and after the device. The device also has four test cocks on it. The spring-loaded check valves close tight when the water pressure flowing through the device drops below 1 psi or when the flow reverses. If one check valve fails to close, it does not affect the operation of the other check valve. It will still close tightly. (NOTE: The double check should not be used to protect the potable water system from Class III substances.)

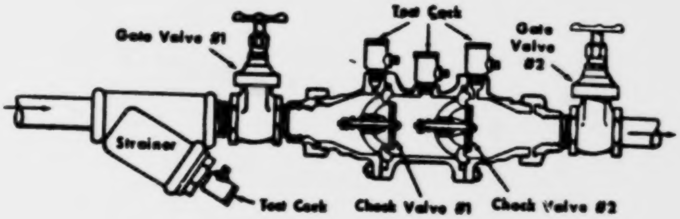


Figure I-9m-4. A Double Check Valve

REDUCED PRESSURE PRINCIPLE BACKFLOW PREVENTER. This type of backflow preventer (figure I-9d-5) may be used on all direct connection-type systems to prevent the backflow of all three classes of substances into the potable water supply. This device is used in continuous pressure systems subject to back-pressure or back-siphonage. It has two independently operating, spring-loaded check valves in the body. A pressure differential relief valve is located in a reduced pressure zone between the two check valves. Shutoff valves are installed before and after the device. Four test cocks are installed on this device for testing.

During the normal operation of this device, both of the check valves are open and the relief valve is closed. The first check valve reduces the supply-line pressure by a predetermined amount. This is so that during normal flow, and at cessation of normal flow, the pressure between the two check valves will be lower than the supply-line pressure. Both check valves close, and the relief valve stays closed when back-pressure occurs. If either check valve fails to close during back-pressure, then the relief valve opens, discharging water out of the zone. The relief valve will stay open until the pressure in the zone drops below the supply-line pressure. In the event of back-siphonage, both check valves close and the relief valve opens, fully discharging the water in the zone.

NOTE: This is the most positive mechanical backflow preventer.

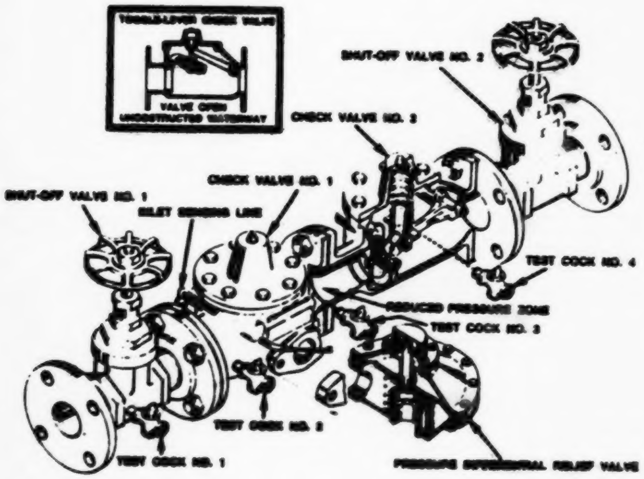

TOGGLE-LEVER CHECK VALVE
VALVE OPEN
UNOBSTRUCTED WATERWAY
SHUT-OFF VALVE NO. 2
CHECK VALVE NO. 2
CHECK VALVE NO. 1
SHUT-OFF VALVE NO. 1
INLET SENSING LINE
TEST COCK NO. 4
REDUCED PRESSURE ZONE
TEST COCK NO. 3
TEST COCK NO. 2
TEST COCK NO. 1
PRESSURE DIFFERENTIAL RELIEF VALVE

Figure I-9m-5. A Reduced Pressure Principle Backflow Preventer

Maintenance

Any installed mechanical device will require some type maintenance and repair from time to time. When working on any backflow preventer you should use and follow the manufacturers' specifications. The following discussion will only cover these devices in general terms.

AIR GAP. Remember the description of an air gap; we are talking about a forced air space. No maintenance is required except to insure that the air gap meets the standards, no hose attached, no pipe extended on the like.

ATMOSPHERIC VACUUM BREAKER. Very little can go wrong with an atomspheric vacuum breaker. If left under prolonged pressure the disc on the air side of the poppet may stick. If this happens it is simple to remove and replace. Sometimes the entire poppet may need replacing.

PRESSURE VACUUM BREAKER. The pressure type vacuum breaker requires periodic testing to insure it operates. Most of these devices have replaceable disc and seats. The springs may need to be replaced in they become weak or broken. If test cocks leak replace them. The shut off valve can be repaired or replaced.

DOUBLE CHECK VALVE. Double check valves too must be tested periodically. If test indicates need, repairs should be made. Disc, seats, and springs may be replaced. Test cocks are replaced when needed. The shut off valves may be repaired or replaced.

REDUCED PRESSURE PRINCIPLE DEVICE. The check valves in the RP are maintained the same as those in a double check. Be sure when you reassemble the device that the heavy spring goes in the front check valve. The relief valve is somewhat different. You may need to replace the diaphragm or unplug the bypass line or port. You can replace the disc, seat and spring.

SUMMARY

In this section the operation and maintenance of backflow preventers has been covered very briefly. If you are going to work on these devices be sure you have the manufacturers instructions and follow them.

EXERCISE I-9m

Complete the following by filling in the blanks. You may use the study guides or your notes.

1. An air gap is a ________________ ________________ between the supply line and the receptacle.

2. The only positive backflow preventer is an ____________________.

3. Atmospheric vacuum breakers are held open by _____________ ___________.

4. On a pressure vacuum breaker the air port poppet is opened by _________ __________.

5. A double check valve may be used when the backflow could be caused by either

____________________ or __________________.

6. Reduced pressure principle devices may be used on class ________, _______, or

____________ hazards.

7. If the poppet sticks open on an atmospheric vacuum breaker replace the __________.

8. On a pressure vacuum breaker a weak spring should be _________________.

9. The seal on a double check valve is badly scratched, it should be _______________.

10. The mechanical device which provides the most positive backflow prevention is a

____.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instructions, do so. The progress check is prepared as a separate publication and controlled by your instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

STANDBY ENGINES

In an operation such as water/wastewater treatment plants, we depend on electrical power to drive pumps, lift stations, and related equipment. When a power loss occurs, some means must be provided so operations can continue. To meet these emergencies we use standby engines.

In this lesson we will discuss the purpose of components, operation, and operational checks on standby engines.

Use of Standby Engines

There are two general purposes for which standby engines are maintained and operated.

EMERGENCY ELECTRICAL POWER. There are many things which can cause loss of electrical power and these power losses may be of a short or long time span. To provide backup electrical power for these emergencies we use gasoline or diesel engines to drive electrical generators. These emergency generators are normally not large enough to provide electrical power to operate all the equipment, but will provide sufficient power for only the essential equipment. Emergency power units may be portable or installed.

STANDBY POWER. A unit for standby power would be one which could be connected direct to the equipment to replace the electrical drive motors. This type installation only handles one part of the equipment although in some cases one engine may be connected to more than one piece of equipment.

OPERATIONAL CHECKS

Pre-operational Checks

1. A visual check of fuel, oil, and water; add if necessary.
2. Check accessories and drives such as carburetor, generator, regulator, starter, belts, fan, fan shroud and water pump for loose connection or mountings.
3. Check engine for leaks (water, oil or gas) and then trace all leaks to the source, and repair or report them to the proper authority.
4. Check battery and voltmeter.
5. Start the engine and let it warm up before putting it under load.

Operational Checks

1. After you start the engine, check instruments, oil pressure, ammeter, tachometer, fuel gauge, voltmeter and temperature gauge.
2. After the engine is warmed to operating temperature, apply a load to engine and check controls periodically to make sure engine is operating properly. If any unusual noises occur, shut down the engine and notify the service call desk. If engine performs well under load, check the engine periodically to assure it continues to function properly.

Post Operational Checks

1. After the engine is shut down, check the water and oil level and service if necessary, report any leaks that have developed.
2. Give engine a complete visual check.
3. Clean air cleaner and breather caps if dirty.

4. Change engine oil and filter at the elapse of specified engine running time.

5. Check fuel filters.

6. Check engine controls.

7. Check for leaks.

8. Check gear oil levels.

SUMMARY

Standby engines are vital to operation of a plant under emergency conditions. These engines should be maintained in accordance with manufacturers' directives and locally devised check lists or procedures.

EXERICISE I-9n

PROCEDURES

Complete the following statements from the information in the study guide.

1. Standby engines are used for ____________________ and ___________________________,

2. Emergency power units may be _____________ or _________________.

3. On a preop inspection check levels of ________, _________, and __________.

4. During operation an unusual noise is heard, you _____________ ______ ______ ________.

5. After use fluid levels should be ____________________________.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review sme of the previous instructions, do so. The progress check is prepared as a separate publication and controlled by your instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INTRODUCTION

Pumps are used extensively throughout our career field for a variety of reasons. they can be used to move water, wastewater or other liquids, as chemical feeders or to provide pressure for water systems.

Types of Pumps

Pumps are classified according to both design and use and they include five major types. They are: velocity, displacement, air lift, turbine, and ejector.

VELOCITY. The three types of velocity pumps are centrifugal (vertical or horizontal), axial flow or mixed flow pumps.

Centrifugal. A centrifugal pump consists of rotating impeller, an impeller casing, and a flow receiving chamber. The impeller is a radial group of vanes curved backward from the direction of rotation and may be mounted directly on a shaft or on a single disk (open impeller). The impeller and casing are usually enclosed by a flow receiving chamber with a volute or progressively expanding spiral passage. The cross-sectional area of the volute increases toward the point of discharge. Centrifugal pumps have many forms, such as single or double suction or single or multiple stages. A horizontal, double suction, volute pump is illustrated in figure I-9o-1.

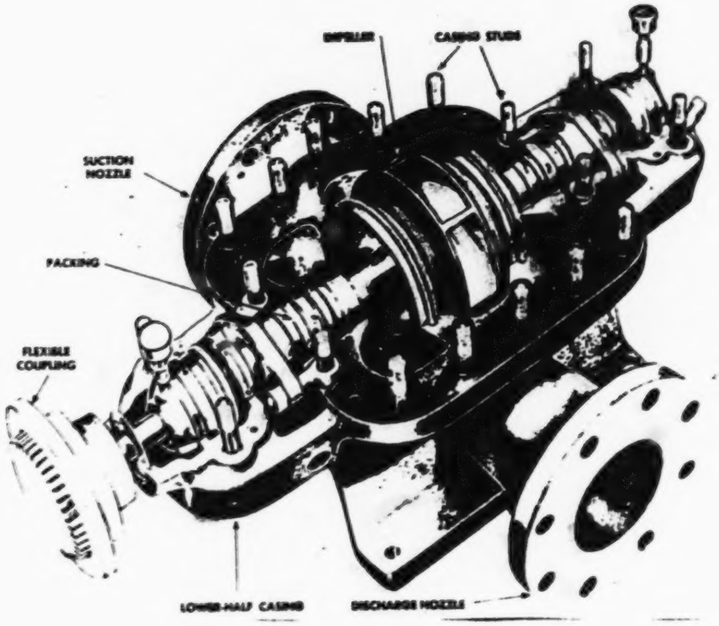


Figure I-9o-1. Horizontal Split-Case Double-Suction Volute Centrifugal Pump

Centrifugal pumps are the most commonly used type of pump in the water systems because they are well adapted to electric drives and a wide variety of operating conditions. For reliable operation, suction head should not exceed 15 feet. Multiple stare centrifugal pumps are used where high discharge pressures are required.

By observing the following operating precautions, you will eliminate many of the commonly encountered problems with centrifugal pumps.

(1) Fill centrifugal pumps with water before you start them. This procedure known as priming lubricates the close-fitting sealing rings and packing. Priming also prevents a condition known as cavitation. Cavitation, caused by the air in an unprimed pump, results in pitting of the impeller and casing.

(2) Make certain that suction piping is airtight.

(3) To operate at the designed capacity, keep the rotation speed and total head as close to design figures as possible. When the total head is less than that for which the pump is designed, the motor may overload and overheat.

Axial-flow pumps. Axial-flow pumps, also known as propeller or screw pumps, have a rotating impeller ressembling the propeller of a ship, a cylindrical casing and a slightly expanding annular discharge passage (figure I-9o-2). Axial-flow pumps are suited only for very low head (5 to 30 feet) and high capacity service. Their principle use is for industrial irrigation and storm water pumping.

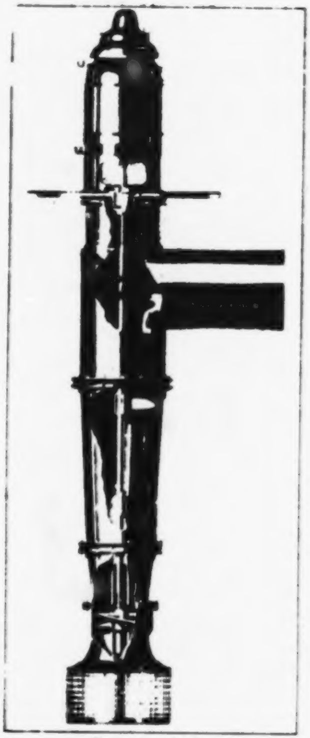


Figure I-9o-2. Vertical Axial-Flow Pump with Screw Type Impeller

Mixed Flow Pumps. Mixed flow pumps are similar to centrifugal pumps, with the exception that the impeller discharges water in a path inclined on the axis of the shaft. The flow receiving chamber is either a volute passage or an expanding discharge pipe similar to that of an axial flow pump (see figure I-9o-3).

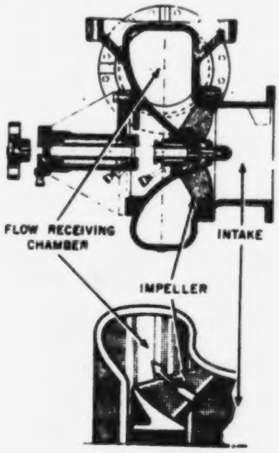
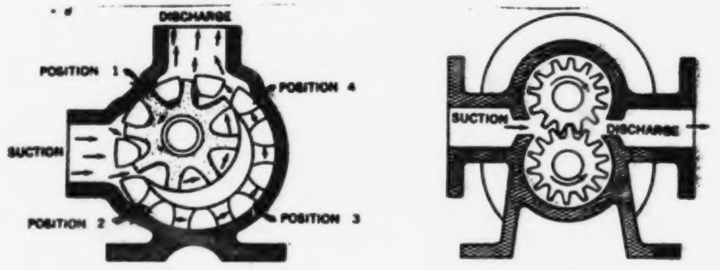

FLOW RECEIVING CHAMBER
INTAKE
IMPELLER

Figure I-9o-3. Mixed-Flow Pumps

DISPLACEMENT. Displacement pumps may be rotary or reciprocating pumps. They are called displacement pumps because the fill a chamber with a liquid and the displace that volume of liquid.

Rotary. A rotary pump is built with a stationary casing and one or more rotating elements. Figure I-90-4 shows four of the many types of rotary pumps, all with the same general principle of operation. Rotary pumps are used in water works for priming larger pumps and for limited special applications. Rotary pumps discharge water in a smooth even flow.

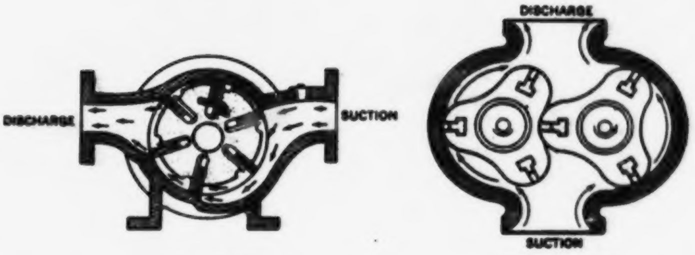

DISCHARGE
POSITION 1
POSITION 4
SUCTION
POSITION 2
POSITION 3
SUCTION
DISCHARGE

INTERNAL-GEAR TYPE

A

SPUR OR EXTERNAL-GEAR TYPE

B


DISCHARGE
SUCTION
DISCHARGE
SUCTION

SLIDING-VANE TYPE

THREE-LOBE TYPE

D

Figure I-9o-4. Several Types of Rotary Pumps

Reciprocating. Reciprocating pumps get their name from the reciprocating or back and forth motion they use to operate. The three types of reciprocating pumps are piston, plunger and diaphragm.

Piston pumps. A piston type pump has a piston which fits tightly and operates inside a cylinder. The pump may have a direct or belt drive and may be single or double acting. Most of the piston type pumps you will see in this career field will be used for sludge pumping. Figure I-9o-5 shows a horizontal piston pump, although, piston pumps may also be vertical.

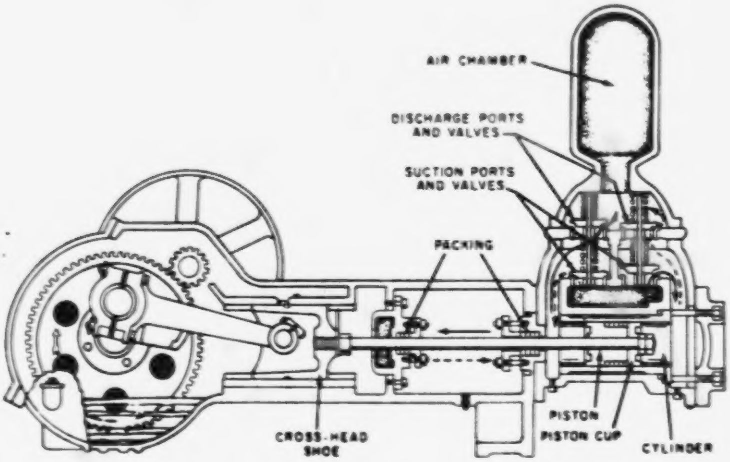


Figure I-9o-5. Belt-Driven Self-Oiling Piston Pump,
Single-Cylinder, Double-Acting Type

Plunger pumps. Plunger pumps operate similar to piston pumps. On the suction stroke the plunger draws liquid in through the inlet port and into the displacement chamber. The discharge stroke of the pumps plunger exerts pressure on the liquid, causing the inlet check valve to seal and forcing the liquid through the outlet port. Figure I-9o-6 shows a reciprocating well pump which uses a plunger.

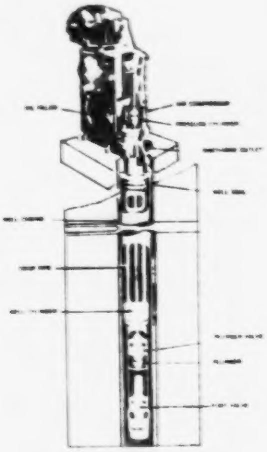


Figure I-9o-6. Reciprocating Well Pump

Diaphragm pumps. Diaphragm pumps also operate basically the same way as do piston pumps. The major difference is that the diaphragm separates the liquid being pumped from the moving parts of the pump. The chemical feeders you worked on earlier in this block were diaphragm pumps. In addition to being able to pump chemicals, diaphragm pumps can be used to move sludges and other thick liquids such as mud.

AIR LIFT. Air lift is a method of raising water by compressed air. The principle of operation is illustrated in figure I-9o-7. If the U-tube is filled with water, the water stands at height H in both legs of the tube. When compressed air is introduced as shown in the figure, a mixture of water and air is formed in one leg. The solid column of water W weighs more than the air-water column P, forcing it over the top of the U-tube. The pressure required for pumping depends entirely on the submergence; the height to which the water must be raised has no effect. The starting pressure is always greater than the working pressure after the well pumping level is reached. If drawdown is excessive, the high starting pressure may require an auxiliary compressor connected in series with the main compressor and receiver. The auxiliary compressor is operated only during starting.

Air lift pumps are useful for groups of wells discharging to a ground storage point served by a single compressor installation. Lower efficiency is offset by a lack of maintenance problems because there are no moving parts in the water. They are particularly adapted for emergency deep well pumping, using a portable air compressor for power. Air lift pumps cannot be used for direct pumping to a distribution system or for horizontal transmission of water. The added oxygen in air lifted supplies tends to make water more corrosive.

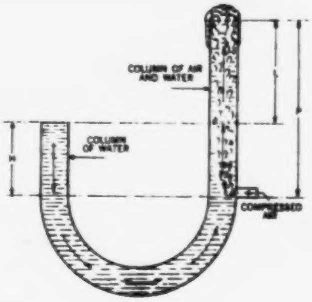


Figure I-9o-7. Principle of Air Lift

TURBINE. A turbine pump has a disc shaped impeller with many small radial vanes near the edge. The inside of the casing is channeled around the impeller vanes, providing water passage from the suction port to the discharge port (figure I-9o-8).

Turbine pumps are used for high head, low capacity service. They are commonly used for booster pumps for vacuum feed chlorinators.

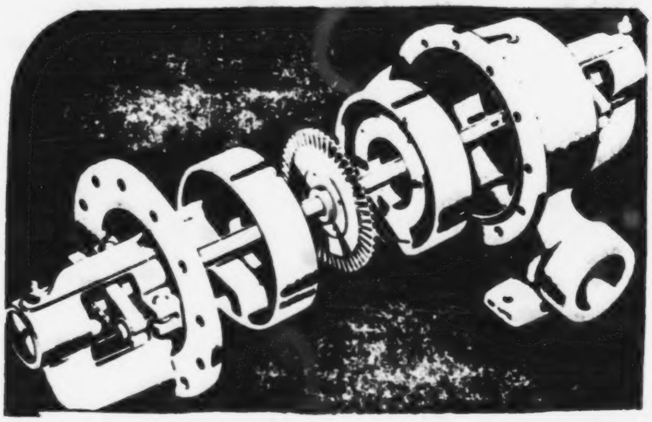


Figure I-9o-8. Impeller and Housing of Turbine Type Pump

EJECTOR. An ejector well pump consists of a centrifugal type single impeller pump located above ground and a stationary ejector assembly in the well. The ejector assembly is made up of a nozzle within a tube which tapers down to a narrow throat opening at the top of the nozzle (Figure I-9o-9).

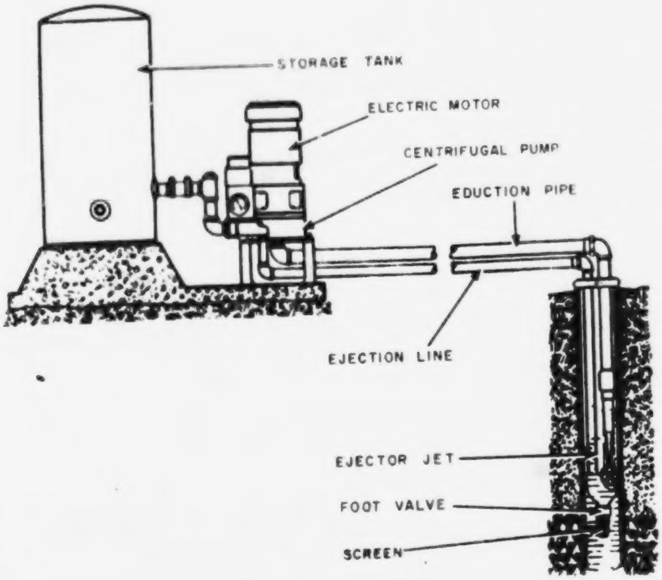

STORAGE TANK
ELECTRIC MOTOR
CENTRIFUGAL PUMP
EDUCTION PIPE
EJECTION LINE
EJECTOR JET
FOOT VALVE
SCREEN

Figure I-9o-9. Ejector Pump Installed Away from Well

Ejector well pumps are suitable for small wells with limited ranges of depth. Because there are no moving parts in the well, they can be installed away from or directly over a well.

EXERCISE I-9-9o

INSTRUCTIONS

Use SW J3ABR56631 000-I-9 to answer the following questions.

1. What are the five major types of pumps?

2. How can you determine the direction of rotation of a centrifugal pump?

3. What purpose does priming a pump serve?

4. What type of pump is used most frequently in a water system?

5. Explain the principle of operation in a plunger pump.

6. Which type of pump separates the liquid being pumped from the moving parts of the pump?

7. Explain the principle of operation in an air lift pump.

8. What are four types of rotary pumps?

9. What type of service are turbine pumps used for?

10. Where are ejector well pumps used?

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SEWAGE LIFT STATIONS

Purpose of Lift Stations

Most of our wastewater collection systems are non-pressurized systems. This means that the wastewater is allowed to flow by gravity to the delivery point. The main disadvantage to this system is that eventually the sewer line will be too deep to be useful and readily accessible for servicing. Lift stations lift the wastewater from these lower points back to near ground level to allow gravity to take over again.

Principles of Operation

As the wastewater moves along the sewer lines it will eventually reach the lift station. Here it falls into a section of the lift station known as the wet well. In addition to containing the wastewater the wet well will have the level controller in it. The pumps used to move the wastewater may or may not be in the wet well.

Adjacent to the wet well is the dry well. The dry well will contain the electric motors, piping, electrical controls and access to the wet well. The pumps may be located in the dry well.

There are two types of pumps commonly used in lift stations. They are the centrifugal and ejector pumps. These are the types preferred becaused they are not subject to fouling with rags and sticks which wastewater may contain.

Periodic pumping of the wastewater is essential to keep from overlflowing the wet well. Here is where a control device comes into use. Float switches, and electric probes are two of the types of controls that have been previously discussed. Another type of level controller frequently used is the bubble tube. This is really a combination of a pneumatic and electrical control device. It uses a diaphragm which is connected to an air compressor on one side. As the level in the wet well rises it exerts pressure on the diaphragm which closes a switch, starting a pump to lower the level in the wet well.

Lift stations may also have a timer to run the pumps during low flow periods. This prevents septic conditions in the lift station thus preventing odor problems.

Types of Lift Stations

There are two distinct types of lift stations. They are the combined design and separate design. Both types may be prefabricated.

COMBINED DESIGNED. In a combined designed lift station the pumps and the wastewater are both located in the wet well of the lift station. The motor and discharge piping are located in the dry well.

SEPARATE DESIGN. The separate design lift station has a wet well and dry well just like the combined design. The exception is that the pumps are housed in the dry well. There is piping connecting the suction side of the pump to the wet well. This type of design allows for easy maintenance of the pumps.

Safety

Safety around lift stations is imperative at all times. Toxic gases can collect in the lift station due to the decomposition of the wastewater. Many people have died in lift stations because of the accumulation of methane gas. For this reason the Air Force has made use of gas detectors mandatory. Besides the toxic gases, electrical hazards are also present. Anytime you use fresh water in a lift station it is important that you prevent backflow using the appropriate backflow preventers.

Operation of the Trainer

This trainer represents a combined design lift station. It is intended to provide realistic training in the operation of a sewage lift station. Incorporated into the trainer are two non-clog sewage ejection pumps, a mechanical alternator/float switch, high water alarm and motor starting contactors.

To operate the trainer, follow the operating instructions in progress check I-9-9p.

EXERCISE I-9-9p

INSTRUCTIONS

Use SW J3ABR55631 000-I-9 to answer the following questions.

1. What is the purpose of a sewage lift station?

2. What two types of pumps are commonly used in lift stations?

3. Name three ways the level is controlled in the wet well?

4. What are the two sections of a lift station?

5. What are the two types of lift stations?

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

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Maintenance of Lift Stations

To insure a trouble free operation, lift stations must have continuing maintenance performed. There are many makes and types of equipment, therefore instructions cannot be given for all of them. The operators will need to make judgment as to whether the information applies to their equipment or will require modification by local command and by manufacturers' instruction. Below are listed the more common maintenance actions required on lift stations.

WET WELLS (Storage Well). Solids must not be allowed to build up on the sides and bottom of a wet well, even if the pump station is automatic. Use the following tips to help maintain the wet well:

1. Draw the sewage level down as low as needed.

2. Flush the sides and bottom of the well with a heavy stream of water and scrape them from time to time. This may require manual working of the pumps.

3. When the wet well pump has no automatic air relief valve, bleed the air trapped in the pump by hand.

4. Remove grit from time to time by using a bucket and shovel if flushing doesn't work.

5. Remove grease in the float tubes from time to time by flushing or scrapping to prevent a build-up. Flushing of the wet well and removing the solids will help reduce odors and harmful gases.

6. If the drinking water system is used for flushing, remove the hose from the well to prevent a cross connection. Safety must be observed when cleaning wells. If keeping the pump station running at all times is important, consider dividing the wet well into two sections so that one section can be cleaned at a time. All pumps and standby units should be tested often. Daily records should be kept at stations where electric power and hydraulic flow are metered and where chemicals are used.

SCREENS AND GRINDERS. Bar and basket screens and grinders installed in pump stations should be cleaned each day to keep trash from blocking the screens and letting sewage back up and overflow.

DRY WELL. The housing structure for pumps, motors and compressors is usually near, but separate from, the wet well. Water, from leakage in the dry well should be removed at least each day by the sump suction valve of a wastewater pump if no separate sump pump is there. The floor of the dry well should drain toward the sump.

STRUCTURES. Structures which house wastewater pumps also need to be well maintained. Pump station floors, walls, and windows must be kept clean to reduce odors and make the place more attractive. Chemicals from wastewater gases can corrode concrete and masonry walls, equipment, steel-work and settings. Good ventilation will help reduce this problem. Forced ventilation is needed in stations built underground. All metal must be protected with paint.

CHECK VALVE SLAM. Check valve "slam" may occur in cases where there is high lift and long discharge piping. Check valve slam can fracture pipes or loosen pipe joints. Installing slow-closing check valves, large air chambers with small compressors to refill the chamber with air, and hydraulic shock absorbers will help reduce this problem.

LUBRICATION. Lubrication is the secret of long lift in any mechanical system. Lubrication may be accomplished by use of zerk fittings, screw type greasers or oil drip containers. Locate all grease fittings and insure this maintenance is performed on a timely basis.

EXERCISE I-9q

Using the lift trainer locate the following components:

1) Control devices
2) Check valves
3) Grease fittings
4) Pump couplings
5) Stuffing box

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

WATER/WASTEWATER FIELD TRIP

Water and wastewater treatment equipment is designed to operate many years without mechanical breakdown. A scheduled maintenance program must be developed and inspections must be performed periodically to insure the equipment is operating efficiently at all times. As an Environmental Support Specialist you must be able to recognize potential equipment failure and be prepared to repair any defect as rapidly as possible.

Subjects in this unit of instruction will give you an overall view of an operating lift station, water pumping station and a wastewater plant. While on a field trip of these facilities, note the maintenance being performed. Pay particular attention to the components discussed in this unit. You will be given a progress check on identifying the condition of these items.

Water Pumping Station

Sheppard Air Force Base is similar to any small city in the United States. It contains a residential area and industrial complexes. The base requires potable water for consumption, recreation and firefighting. To deliver this water, a complex design of support components are required. These components must be well maintained in order to provide uninterrupted water service to this base.

VALVES. Numerous types of valves are required in a water treatment facility. The maintenance required on valves is minor, however, the maintenance stated in AFR 91-26 must be performed to insure operation.

Altitude Valve. This valve is located at the base of the water tower. It's purpose is to maintain a pre-set water level in the tower. These valves operate by atmospheric pressure which causes it to open and close. Failure of this valve will result in low water level or overflowing of the tank.

Pressure Regulating Valves. There are two sixteen inch regulating valves installed on the distribution lines at the base of the tower. These valves operate on line pressure to maintain a constant pressure on the main distribution system. This valve is vital because it prevents over-pressurization which will cause damage to the water distribution system. Notice the smaller regulator attached to the larger one. This is a pilot regulator which controls the operation of the larger valve. Most regulators have strainers installed to keep sand out of the operating mechanism. Cleaning the strainer periodically will extend the life of these valves. Gauges on these regulators are critical for presenting accurate readings and making adjustments in pressure.

Gate Valves. There are numerous gate valves installed in the water plant. Sizes range from 3/8" up to 16". Maintenance consists of repacking the gland and oiling the stem. Accomplishing this maintenance along with the periodic opening and closing of the valve will insure its proper operation when an emergency exists.

CHEMICAL FEEDER. After the water enters the water treatment plant, it is treated with chlorine by a chemical feeder. This insures the proper amount of disinfectant is added to maintain a safe potable water. The type feeder used here is a solution feed, vacuum type, "V" notch gas chlorinator. This feeder draws chlorine from the storage cylinder by a vacuum created by a booster pump. Proper adjustment of this feeder is essential to safe potable water.

PUMPS. Following the chlorination process, the treated water is directed to the booster pumping facility. This facility utilizes six centrifugal pumps. There are three 50 horsepower, 500 gallon per minute electric pumps and two, 2000 gallon per minute diesel powered pumps installed. Normally, only one electric pump is required to maintain distribution system pressure. In case of high water demand, other pumps may be operated in tandem. Diesel pumps are used primarily in event of power outages. Maintenance is essential to these pumps. Continuous operations places excessive wear unless the unit is properly lubricated.

ELECTRIC MOTORS. Electric motors are the most common drive mechanisms used in military water systems. When servicing the pump, also lubricate the motor bearings. Insure all mounting bolts are tight.

Motor Couplings. Motor couplings are used to provide a physical connection between the motor and pump. They are designed to absorb shock and torque between the two units. They are not intended to allow for misalignment between the pump and motor. Coupling alignment must be within .005 inch and securely tightened. There are two types of misalignment of couplings. They are parallel and angular misalignment. Parallel misalignment is when the outside edges of the couplings do not meet at a 180° angle. Angular misalignments occurs when faces of couplings are not square.

Power Take-off Assemblies. Power Take-off assemblies are similar to a motor coupling, however, they are utilized with the diesel engine and pump. The Power Take-off assembly operates like a clutch on an automobile. When engaged, they are the physical connection between the motor and pump. Inspection of these devices is always performed during normal operating conditions. Maintenance services to this equipment will be performed in accordance with manufacturers manuals.

CONTROL DEVICES. Pressure activated control devices are located on each pump. They activate due to the amount of pressure on the discharge side of the pump. Insure the pumps activate at the set pressure and adjust accordingly.

TANKS. This facility has three ground storage tanks with a total capacity of 2 million gallons. These three tanks supply the .5 million gallon elevated storage tank. This elevated storage tank is the pressure source for the base distribution system. Note the condition of the tank. There should be no corrosion apparent.

MEASURING DEVICES. A venturi meter and chart recorder is used to measure the incoming flow. A turbine meter is used to measure the effluent of the plant. These meters will require periodic calibration to maintain accurate readings.

Wastewater Treatment Plant

Wastewater is treated at the base wastewater treatment plant. Components for wastewater treatment are similar to water treatment equipment. In the following unit, we'll discuss components of the wastewater plant.

PUMPS. Piston type pumps are used in the movement of sludge from the primary settling tanks to the digester. They are also used to move sludge from the secondary clarifiers to the head of the primary tanks. You can see why maintenance of these pumps is essential.

VALVES. Gate valves are used at various points throughout the plant and your instructor will point out their location. Remember, gate valves are for full operation and should not be throttled. Plug valves are located on the primary and secondary settling tanks and are used in controlling the flow of sludge. Most plug valves have a grease fitting located directly on top. Globe valves are located between the digester and are used to transfer sludge between them. Globe valves are used when it is necessary to throttle the flow.

CHEMICAL FEEDERS. A "V" notch gas chlorinator is located in the chlorine room. Its operation and maintenance is the same as mentioned in the water plant.

MEASURING DEVICE. A Parshall flume is located at the head of the plant. Presently this item is not being used. An ultra-sound measuring device measures the incoming flow. This device operates a sonar wave directed toward a pre-determined size channel in the influent flow. This device measures the distance from the transceiver to the surface of the wastewater flow. This distance is converted into gallons of total flow.

CONTROL DEVICES. Float or mechanical control devices activate the pumps which recirculate the wastewater back to the high rate trickling filter. Adjusting the float level is necessary periodically.

ELECTRIC MOTORS. Electric motors located throughout the wastewater plant are sealed type. They present no electrical explosion hazard when exposed to flammable gases.

SAFETY. As in all aspects in military service, safety is a number 1 priority. As an Environmental Support Apprentice you are and will be exposed to a number of safety hazards. The following are areas you should be constantly aware of:

Falls
Improper Lifting
Electrical Shock
Use of Sharp Edged Tools
Infections
Working in Oxygen Deficient Areas
Toxic Dusts
Dangerous Chemicals
Fire Prevention
Toxic, Flammable Gases and Vapors

There are several basic safety measures that can be taken to help prevent accidents. These apply to all aspects of water/wastewater treatment and distribution work.

Safety Record Keeping
Locating and Correcting Safety Hazards
Equipment, Plant Arrangement, and Working Methods
Personal Protective Equipment
Safety Instructions
Fire Protection
Power Drives and Shaft Guards
Adequate Help and Teamwork
Protection of the Public

EXERCISE I-9r

Answer the following True or False

1. Altitude valves are found at the wastewater plant.

2. Lift stations are required to move wastewater from a lower elevation to a higher elevation.

3. A motor coupling acts on the same principle as a clutch in an automobile.

4. Sealed type motors are required in water treatment plants.

5. Pressure activated control devices are located on the discharge piping of centrifugal pumps.

6. Motor couplings are designed to correct misalignment between pumps and motors.

7. Plug valves do not require lubrication.

8. Periodic monitoring and calibration is required to chlorinators.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

By reading this study guide on the maintenance of drive equipment and accessories, you can now realize the importance of preventive maintenance. It is your job to know how and when to realign, oil, grease, clean and paint operating equipment. Also, you must know how to repair or replace parts of equipment that show signs of wear or deterioration. If a piece of equipment does break down or fails to function properly, follow the manufacturer's specifications and instructions for repairing the piece of equipment or refer to AFR 91-26 and AFM 91-32.

Inspection of operating equipment must be conducted at certain times and during operation of the euqipment to insure proper running. In this way, you can detect trouble in the equipment before it becomes serious. For example, let us take a gasoline engine driving some type of equipment. When you inspect it and find that it has no oil pressure you must shut the engine down and check it over and find if it is just low on oil or maybe an oil line broke causing the loss of oil pressure. At any rate, you have saved the engine from burning up, and with a few minor repairs it is off and running again.

You also have to know what to look for when you are inspecting the equipment at treatment plants. This study guide should have given you the basic knowledge of what to look for when you inspect the drive equipment at treatment plants and how to take care of this equipment.

Most methods of water treatment involve the addition of some type of chemical to the water. To feed these chemicals under controlled conditions, we must use chemical feed pumps. The three main types of chemical feeders are gas feeders, solution feeders and dry chemical feeders. The best way to keep the chemical feeders operating properly is by strict adherence to the preventive maintenance schedules, as prescribed in AFR 91-26

Due to close tolerances used in the manufacture of water meters sticking or binding may develop from accumulations of scale and sand or the use of hot water. When trouble develops you should clean the meter and check it for accuracy. A check with another dependable water meter is accurate enough for normal water treatment control purposes.

Recorders are sensitive instruments. You should handle them with care to prevent damage. To perform daily servicing of recorders, change the chart, align the chart for the correct time, and check the ink supply. Keep the charts as a daily record of total plant flow.

Leaky or inoperative valves are another problem common to the distribution system. Valves should always be kept in good operation for proper control of water flow. The most widely used types of valves are the gate, globe, and check valves.

Back siphonage can become a health hazard. Where the possibility of back siphonage could exist, backflow preventers must be installed.

Many pumps are required in both water and sewage plant operation. These pumps are classified according to design and use. Since pumps are subject to malfunction, you must be familiar with the commonly encountered types of pumps and to be able to perform maintenance on them.

Maintenance of sewage treatment equipment is not an every day job; however, inspection of the equipment is a constant job.

Anytime you look at the grit chamber, bar screen or comminutor, you are observing for operation, unusual noises or anything out of the ordinary.

Sewage treatment equipment must be kept in good operating condition and occasionally cleaned. Exposed iron must be protected from corrosion, worn parts removed and replaced, tanks occasionally drained and hosed down.

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PUMP AND EQUIPMENT MAINTENANCE

OBJECTIVES

Given a centrifugal pump, and working as a team, disassemble, inspect and reassemble the pump with no more than two instructor assists.

Using the water pump trainer and working as a team, remove, disassemble, inspect, reassemble and install the pump to its operating condition with no more than two instructor assists.

INTRODUCTION

Pumps are machines, and being machines, you must perform minor maintenance to keep them in operating condition. Some of the problems that you may encounter are, setting up a pump, changing the packing, alignment of the coupling, and priming.

There are two main topics in this chapter titled:

- MAINTENANCE OF PUMPS
- PUMP INSTALLATION

INFORMATION

MAINTENANCE OF PUMPS

Selecting the Proper Tools

Before beginning any maintenance on any piece of equipment, it is necessary to inventory your tools to insure the needed tools are there.

Pump Disassembly and Components

A manufacturers checklist is used for disassembly procedures in the field. For our purposes here you will receive an SOP on pump maintenance. It will describe the procedures to follow when disassembling a pump.

COMPONENTS. The components you will encounter while performing maintenance on a centrifugal pump are many. What follows is a brief description of each of these components.

Stuffing box, packing, lantern ring and packing gland. The stuffing box is located around the shaft at one end. It contains the packing and the lantern ring (Figure I-10a-1). The packing used in our pumps is made of asbestos fibers soaked in graphite. It prevents excess leakage from the main cavity of the pump. The lantern ring lubricates the packing by allowing a liquid to enter from an outside supply. Finally, the packing gland is used to compress the packing to provide a better seal or prevent leakage.

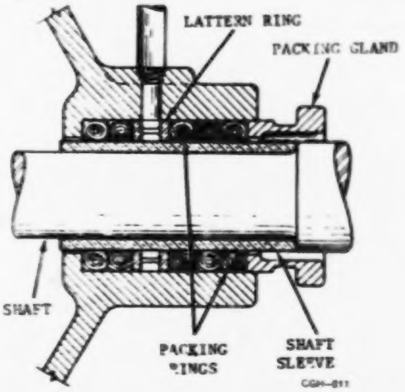

Figure I-10a-1

If the liquid pumped is dirty, gritty, or is acidic; pipe a sealing liquid to the stuffing box from a clean outside source in order to prevent damage to the packing and shaft sleeve.

Fit the pipe supplying the sealing liquid tightly so that no air enters. On suction lifts, a small quantity of air entering the pump at this point may result in loss of suction.

Always remove and replace all of the old packing. Do not reuse some of the old rings because they "look" all right. If, for instance, you replace only the outermost accessible rings, then they will be the only rings compressed when you tighten the packing gland. As a result, the new rings will have to do all the work of sealing the box and accelerated packing wear will result. The old rings, having been previously compressed, will move as a unit and fail to provide a good seal.

To remove packing, use a puller, as illustrated in Figure I-10c-2. It consists of a short corkscrew section, on the end of a piece of flexible wire, attached to a handle. If the packing should break up while being pulled out, remove all the broken pieces to insure a clean and clear stuffing box before you insert the new packing. A small piece left in the box will make it impossible to repack the pump properly.

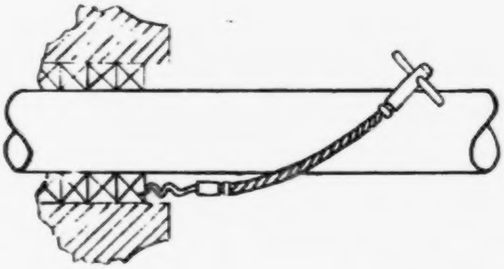

Figure I-10a-2

If the new packing is slightly large, never try to flatten it with a hammer. Place the packing on a clean flat surface and roll it with a piece of pipe until the thickness is such that a slight effort is required to push it into the box. When you place a ring of packing over the shaft, do no pull the ends apart. Twist it over the shaft as shown in Figure I-10a-3.

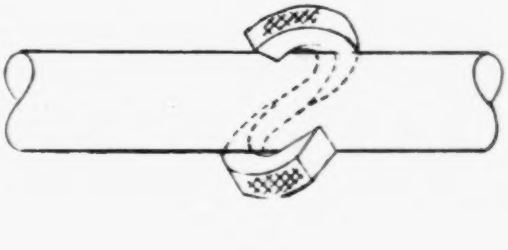

Figure I-10a-3

Tamp each ring into place. This may be done with a dummy gland which can be a split sleeve of metal or wood which fits over the shaft. The outside diameter should be slightly smaller than that of the stuffing box bore. The last few rings may be pushed into place using the packing gland.

Stagger the packing ring joints as you install each ring (180° apart if only two rings, are used, 90° apart for three or more rings).

Install the lantern ring so that when the packing is compressed it lines up with the cooling liquid opening. When you unpack the box, note the arrangement of the gland and the number of packing rings behind and in front of the lantern ring, and repack in the same way.

When you have the box fully packed and the last ring is firmly tightened with the gland, rotate the shaft a few times by hand to "Glaze" the packing. Then back off the gland nuts and retighten finger - tight only. This allows the packing to expand as it warms up.

Important. Many pump failures occur because inexperienced maintenance personnel see liquid dripping from a gland and try to stop it by tightening the gland bolts. For a very short period the leakage will stop. The packing then becomes overheated and burns or scores the shaft sleeve and the pump must be shut down.

A requirement of all packings is that they be lubricated at all times and this requires constant leakage. When the gland is properly adjusted and the packing has been "run in," only a few drops of leakage a minute are necessary, but it is essential. Three to six drops is the recommended rate.

You must take care when you tighten the gland so that it remains square to the shaft. To do this tighten the gland bolts alternately only a slight amount at a time. If you do not do this, shaft sleeves may be scored by contact with the inner edge of the gland, and the scored area could lead to rapid packing failure.

Volute and Casing. The volute and casing serve to house the impeller. The volute is a progressively expanding chamber which changes the liquid velocity into pressure.

Impeller. The impeller is a circular disc with vanes curved backward to the direction rotation. It moves the water through the pump.

Shaft Sleeve. The shaft sleeve is located on the shaft and is designed to protect the shaft from excessive wear and tear.

Shaft. The shaft runs the length of the pump and supports all the pump components.

Bearings. Bearings are located on the shaft. They allow the shaft to rotate freely without excessive wear. Bearings may be either sealed or open type bearings.

Water Seal. The water seal or slinger is also located on the shaft. It prevents water from entering the bearings.

Coupling Alignment

A minimum dimension for the separation of the coupling halves is usually specified by the coupling manufacturer.

The tools you will need to check the alignment of a flexible coupling are a straight edge and a taper gauge.

Make the check for angular alignment by inserting the taper gauge at four points between the coupling faces and comparing the distance between the faces at four points spaced at 90° intervals around the coupling. The unit will be in angular alignment when the measurements show that the coupling faces are the same distance apart at all points (Figure 10-4).

Make the check for parallel alignment by placing a straightedge across both coupling rims at the top, bottom and at both sides. The unit will be in parallel alignment when the straight edges rest evenly on the coupling rim at all positions. Allowance may be necessary for temperature changes and for coupling halves that are not of the same outside diameter. You must take care to have the straight edge parallel to the axis of the shafts (Figure 10-4).

Correct angular and parallel misalignment by adjusting the shims under the pump or driver, or relocating units on the baseplate. After each change, you must recheck the alignment of the coupling halves. Adjustments in one direction may disturb adjustments already made in another direction.

Flexible couplings are not universal joints. You should take the same care in the alignment of equipment using flexible couplings as if solid couplings were to be used.

No permissible misalignment standard can be established. What might be tolerated in one instance might cause trouble in another. It is good practice to do the best job of alignment possible.

When the units are lined up cold, you may need to make an allowance for the vertical rise of the driver and/or pump, caused by heating.

When you note running vibration and the alignment seems to be correct, do not overlook the possiblity that the coupling bore is not centered; this would require a new flexible coupling.

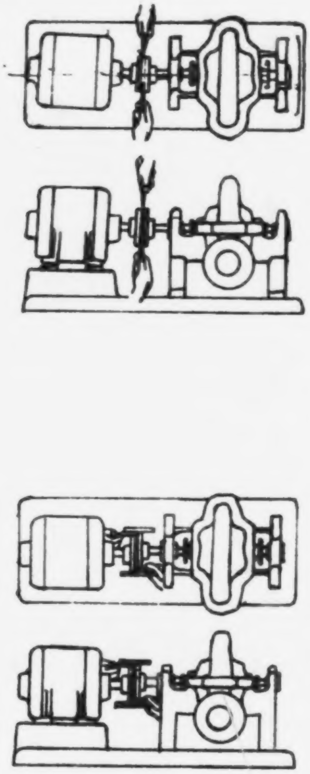

Figure 10-4

Below is a chart that lists many of the operating problems that you may encounter.

TROUBLESHOOTING GUIDE

PROBABLE CAUSE	REMEDY
FAILURE TO DELIVER WATER, OR SUFFICIENT WATER AND SUFFICIENT PRESSURE	
Pump not primed.	Reprime.
Pump not up to speed.	Check for incorrect motor voltage and motor overload.
Discharge head beyond pump shut-off.	Alter installation or provide pump suitable for higher pressure.
Excessive suction lift.	Reduce lift: use larger suction pipe.
Incorrect direction of rotation.	Reverse rotation.
Insufficient positive head on suction for hot liquids.	Give pump more submergence, simplify and increase size of suction piping.
Footvalve too small.	Replace with adequate size footvalve.
Strainer clogged.	Clean out.
Worn bearing ring or damaged impeller.	Recondition or replace worn parts.
High spot or air pocket in suction line.	Repipe to pump suction to eliminate loose and high spots.
PUMP LOSES PRIME AFTER STARTING	
Excessive suction lift.	Reduce lift: use larger suction pipe.
Air leaks in suction line.	Check joints, make up tight with pipe joint compound.
MOTOR OVERHEATS	
Total head is higher than rated.	Larger motor is required. Check with dealer to see if head is in the operating range of the pump.
Liquid handled is of higher viscosity or specific gravity than that for which the pump was designed.	Check with dealer; a larger motor is required.
Mechanical trouble in pump or motor.	Check impeller fit, shaft straightness and ball bearings. See if motor turns freely.
Low voltage or incorrect voltage.	See that power supply is as required, check electrical connections to motor, check to see that wiring to motor is large enough.
PUMP VIBRATES OR IS NOISY	
Impeller partially clogged.	Disassemble pump and clean out impeller.
Insecure foundation.	Rebuild to give rigidity to pump and motor.
Bent shaft, impeller, or worn ball bearings.	Dismantle and replace worn parts.
Misalignment between motor and pump.	Check alignment.

Figure 10-5

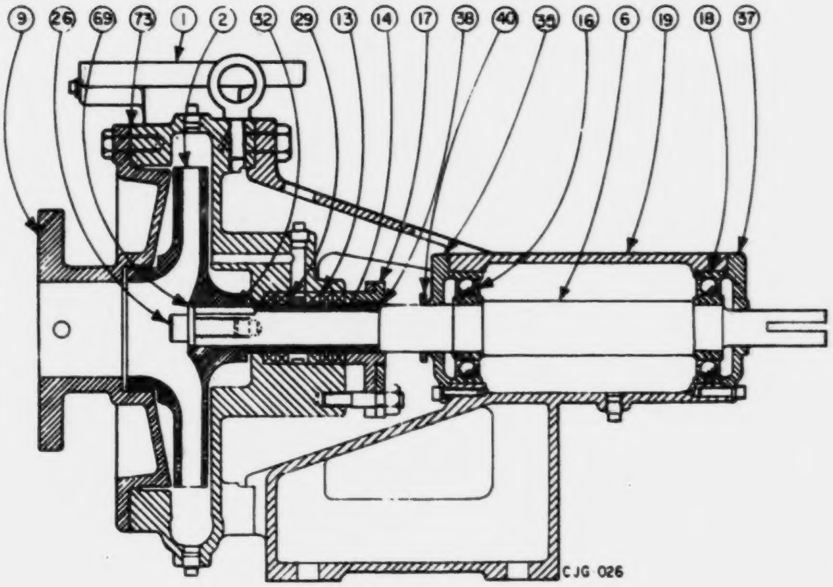
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Figure 10-5. Single Suction Centrifugal Pump

1	CASING
2	IMPELLER
6	SHAFT*
9	SUCTION COVER
13	PACKING*
14	SHAFT SLEEVE*
16	BEARING-INBOARD*
17	PACKING GLAND*
18	BEARING-OUTBOARD*
19	BEARING BASE*
26	IMPELLER SCREW*
29	LANTERN RING*
32	IMPELLER KEY*
35	BEARING COVER INBOARD*
37	BEARING COVER OUTBOARD*
38	SHAFT SLEEVE GASKET*
40	DEFLECTOR*
69	LOCKWASHER*
73	CASING GASKET

*INDICATES INTERCHANGEABILITY AMONG SINGLE SUCTION PUMPS

PUMP DISASSEMBLY/REASSEMBLY

Single Suction Pumps. Refer to Figure 10-6.

1. See coupling manual for coupling disassembly.
2. Drain suction and discharge lines and pump casing.
3. Remove suction and discharge piping from pump flanges.
4. Remove bolts and dowel pins from pump feet. Pump may now be removed from baseplate for bench work if so desired.
5. Remove cap screws holding suction cover (Part 9) to casing (Part 1) and pull suction cover straight out to remove. If suction cover cannot be removed by hand, screw in the two square head jack screws in the suction cover flange.
6. Screw out impeller screw (26). Remove impeller washer (69), impeller (2) and impeller key (32).
7. Remove packing gland nuts and packing gland (17). Packing gland is split type and can be removed from shaft. Pull out front packing (13)-see STUFFING BOXES AND PACKING - and slide lantern ring (29) back against deflector (38). Remove balance of packing.
8. Remove cap screws holding casing (1) to bearing base (19). Casing is now free to be removed. Take care not to score shaft sleeve (14) when you remove the casing.
9. Slip shaft sleeve (14), lantern ring (29), deflector (40) and shaft sleeve gasket (38) from shaft.
10. Remove cap screws from bearing cover - inboard (35) and bearing cover - outboard (37). Remove bearing covers.
11. Shaft (6) and ball bearings (16 & 18) may now be PULLED (or PUSHED) from bearing base (19) in either direction. DO NOT HAMMER SHAFT AND BEARINGS FROM BEARING BASE. If difficulty is encountered in removal, use an arbor press or similar equipment to apply more force. PUSH ON OUTER RACE ONLY!
12. If bearings do not slip off shaft after removal from bearing base, use same precautions for removal as mentioned above. PUSHING ON INNER RACE ONLY!
13. Wrap bearings immediately in clean waxed paper or clean lint-free rags.

ASSEMBLY PROCEDURE

Single Suction Pumps. The assembly procedure is directly reversed from the disassembly procedure, with the following precautions:

1. Give the ball bearings an ample coat of grease or oil just prior to assembly.
2. Push the bearings onto the shaft, pushing against the inner race. Do not hammer on the bearings!
3. For best service, use new gaskets (38 & 73). To prevent casing gasket (73) from sticking to flanges, coat flanges with mixture of flake graphite and motor oil.
4. Draw flange bolts up slowly and evenly.
5. Follow directions in STUFFING BOXES AND PACKING when repacking pump.
6. Check coupling alignment carefully. See COUPLING ALIGNMENT.

EXERCISE I-10-10a

INSTRUCTIONS

Use the pump disassembly/reassembly to complete this performance exercise located on page 10-7.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

EXERCISE I-10-10b

INSTRUCTIONS

Use your SW J3ABR56631 000-I-10 to answer questions.

1. What will be the result, if the packing is pressed too tight in the stuffing box?

   ____

2. How many degrees should the packing be staggered when repacking the pump?

   ____

3. Why must the packing nuts be finger tight after repacking? ______________

   ____

4. What tools are used to check the alignment of a coupling? ______________

   ____

5. What is the purpose of priming a pump? ______________________

   ____

6. What are two causes for a pump to lose its prime after starting? __________

   ____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

Since pumps are subject to malfunction, you must be familiar with the commonly encountered types of pumps so that you will be able to perform maintenance on them.

REFERENCES

1. AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems
2. TM 5-661, Water Supply Systems at Fixed Installations

PROGRESS CHECKS

J3ABR56631 000-I-2 thru 10

Technical Training

Environmental Support Specialist

ENVIRONMENTAL FUNDAMENTALS AND SUPPORT EQUIPMENT

June 1986

3700 TECHNICAL TRAINING WING
3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 63, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

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Supersedes WB J3ABR56631-I-2 thru 10, February 1986

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-2a

CAREER LADDER

OBJECTIVE

Given an excerpt from AFR 39-1, select the information that describes the duties and responsibilities of the 566X1 Career Field. Four of five must be correct.

REFERENCE/MATERIAL/EQUIPMENT

Extract, 39-1

INSTRUCTIONS

1. This progress check consists of 5 items. You must solve 4 items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

From the following list of statements match the descriptive term(s) for each statement. Terms may be used once, more than once, or not at all.

STATEMENT

_________1. Operates water processing plants and equipment.

_________2. Monitors solid waste collection, transportation and disposal processing facilities.

_________3. Completion of basic environmental support course is desirable.

_________4. Operates, maintains, and repairs water supply and water processing plants and systems and wastewater processing plants and systems.

_________5. Completion of high school with courses in chemistry and biology is desirable.

TERMS

a. Special summary

b. Duties and responsibilities

c. Special qualifications

———————— STOP ————————

Before proceeding any further, have the instructor check your work.

_____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-2b

CAREER LADDER

OBJECTIVE

Using the 566X1 career field ladder, list the AFSC titles and the methods of advancing from one step to another. Ten of fourteen must be correct.

REFERENCE/MATERIAL/EQUIPMENT

SW J3ABR56631 000 I-2 thru 10

INSTRUCTIONS

1. This progress check consists of fourteen items. You must solve ten items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

From the following list of job titles, match Column A with the appropriate AFSCs in Column B. AFSCs may be used once, more than once, or not at all.

COLUMN A

________1. Environmental Support Helper

________2. Environmental Support Apprentice

________3. Apprentice Entomologist

________4. Entomology Technician

________5. Environmental Support Specialist

________6. Entomology Support Specialist

________7. Environmental Support Technician

________8. Sanitation Specialist

________9. Sanitation Superintendent

________10. Basic Airman

COLUMN B

a. 99000
b. 56691
c. 56690
d. 56671
e. 56670
f. 56651
g. 56650
h. 56631
i. 56630
j. 56611
k. 56610
l. 56600
m. N/A

Part 2.

INSTRUCTIONS

Write the correct method of advancing from one skill level to the next highest skill level in our career field.

	FROM SKILL LEVEL	TO SKILL LEVEL	METHOD OF PROGRESSION	RANK(S)
1.	56611	56631		AB thru A1C
2.	56631	56651		SrA thru SSgt
3.	56651	56671		SSgt thru MSgt
4.	56671	56691		SMSgt thru CMSgt

STOP

____________Instructor's initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-3a

CIVIL ENGINEERING MANAGEMENT

OBJECTIVE

Given four statements, select the one that best identifies the BCE mission.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of one item. You must solve it correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

Place a check (/) mark to the left of the statement(s) that best explains the mission of a Civil Engineering Squadron.

________1. Making of ice, transportation of ice to facilities.

________2. Operate and maintain aircraft on flightline.

________3. War readiness.

________4. Control, operate and maintain computer machines.

_____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-3b

CIVIL ENGINEERING MANAGEMENT

OBJECTIVE

Given an incomplete BCE organization structure chart, complete the chart by writing the names of the missing functional areas in the appropriate spaces. Three of five must be correct.

REFERENCE/MATERIAL/EQUIPMENT

Organizational Chart (Blank)

INSTRUCTIONS

1. This progress check consists of five items. You must solve three items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

Fill in the blank spaces on the Base Civil Engineering Organizational Chart below.

____________________ STOP ____________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-3c

CIVIL ENGINEERING MANAGEMENT

OBJECTIVE

Using a representative list of functions, responsibilities and a list of CE units, match the functions and responsibilities to the CE unit to which they apply. Six of nine must be correct.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of nine items. You must solve six items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

From the following list of civil engineering functions and responsibilities, match each responsibility statement in Column A to the correct BCE functional areas in Column B.

COLUMN A

________1. Manage and supervise construction and related programs.

________2. Provides fire fighting personnel and equipment.

________3. Build and repair training equipment.

________4. Responsible for providing gas, heating, cooling, water and wastewater.

________5. Record keeping on real estate.

________6. Keep real property and equipment in good living and working condition.

________7. Arrange and coordinate all small to large job programs.

________8. Responsible for clean residences on base.

________9. Cleans buldings, removes snow, and refuse collection.

COLUMN B

a. Training aids

b. Maintenance and repair of structures and equipment

c. Not a function

d. Planning and Programming

e. Engineering and Construction

f. Management of AF real property

g. Services

h. Family Housing management

i. Fire protection

j. Utility service

____________________ STOP ____________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-3d

CIVIL ENGINEERING MANAGEMENT

OBJECTIVE

Define property accountability and responsibility.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of three items. You must solve all items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

Listed below are three terms concerning property accountability and responsibility. Define each term.

1. Pecuniary liability

2. Custodial responsibility

3. Property accountability

---------------- STOP ----------------

Before proceeding any further, have the instructor check your answers.

________Instructor's initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-4a

SECURITY (OPSEC)

OBJECTIVE

Given information pertaining to the operational activities related to AFSC 566X1, select three activities which indicate OPSEC vulnerabilities.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of three items. You must solve all items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

Select three activities that indicate OPSEC vulnerabilities from Column B.

COLUMN A

1. ____________________
2. ____________________
3. ____________________

COLUMN B

a. Prime BEEF exercise
b. Operational indicators
c. Type of water analysis
d. Procedural indicators
e. Type of wastewater analysis
f. Communications indicators

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-5a

TECHNICAL PUBLICATION

OBJECTIVE

Using numerical indexes and requirement tables, locate the title of a manual, a regulation and a technical order when the numbers are known, with no more than three instructor assists.

REFERENCE/MATERIAL/EQUIPMENT

TO 0-1-01
AFR 0-2

INSTRUCTIONS

1. This progress check consists of three items. You must solve all items correctly to receive a satisfactory rating.
2. You are authorized three instructor's assists.
3. When you have completed the progress check, return it to your instructor.
4. If you have no questions, start your progress check.

DIRECTIONS

Write the publication titles to match the list of publication numbers listed below.

1. TO 40W4-9-1 ______________________________

2. AFR 91-26 ______________________________

3. AFM 91-32 ______________________________

______________ STOP ______________

Before proceeding any further, have the instructor check your work.

__________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-5b

TECHNICAL PUBLICATIONS

OBJECTIVE

Using a manual, a regulation, a technical order and a commercial publication, find the answer to a given problem with no more than three instructor assists.

REFERENCE/MATERIAL/EQUIPMENT

TO 40W4-9-1	AFM 91-32
TO 40W4-13-1	AFR 91-26

INSTRUCTIONS

1. This progress check consists of five items. You must solve all items correctly to receive a satisfactory rating.

2. You are authorized three instructor assists.

3. When you have completed the progress check, return it to your instructor.

4. If you have no questions, start your progress check.

DIRECTIONS

Using the available publications in the classroom, locate and write the answers to the problems listed below. There is at least one problem involving the use of each of the following publications: TO 40W4-9-1, TO 40W4-13-1, AFM 91-32, and AFR 91-26.

1. If the reverse osmosis pump shuts down by itself and/or the R.O. pump, low pressure lamp comes on, what action(s) should be taken?

2. What may be the probable causes if diatomite filter elements will not take a precoat?

3. In a wastewater treatment plant using rotating biological contactors, you notice large areas of white biomass forming on the filter media. What is the likely cause and what action should be taken to correct this problem?

4. The softening capacity of a Zeolite bed has been depleted. Locate and list the possible causes or actions to take to correct this problem.

__________________ STOP __________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-5c

TECHNICAL PUBLICATIONS

OBJECTIVE

Given information pertaining to a technical order deficiency, select the action that should be taken to correct the deficiency. Three of the four must be correct.

REFERENCE/MATERIAL/EQUIPMENT

SW J3ABR56631 000-I-2 thru 10

INSTRUCTIONS

1. This progress check consists of four items. You must solve three items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

The following information will pertain to reporting and correcting technical order deficiencies. Circle the correct action to take when a deficiency is found.

1. Select the most correct action which should be taken when a T.O. deficiency is found.

   a. Correct the error using black ink

   b. Fill out AFTO Form 22 and report it to your supervisor

   c. Report the error to your supervisor and make the correction in black ink.

   d. Report the error to your supervisor.

2. When should an improvement report be submitted for action?

3. List the three types of deficiency reports used when submitting AFTO Form 22.

   a.

   b.

   c.

4. What information is entered in the following blocks of AFTO Form 22?

a. Block - 1

b. Block - 2

c. Block - 3

d. Block - 7

e. Block - 8

f. Block - 10

g. Block - 11

h. Block - 12

________________ STOP ________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-5d

TECHNICAL PUBLICATIONS

OBJECTIVE

Using the three parts of a GSA supply catalog and an incomplete list of stock numbers and nomenclatures, locate and list the missing information with no more than two instructor assists.

REFERENCE/MATERIAL/EQUIPMENT

SW J3ABR56631 000-I-2 thru 10
GSA Catalog

INSTRUCTIONS

1. This progress check consists of six items. You must solve all items correctly to receive a satisfactory rating.
2. You are authorized two instructor assists.
3. When you have completed the progress check, return it to your instructor.
4. If you have no questions, start your progress check.

DIRECTIONS

Use a GSA catalog to find the stock numbers and nomenclatures for the following list of missing information.

	STOCK NUMBERS	NOMENCLATURE	UNIT PRICE
1.		Reversible ratchet 3/8", 10"	
2.		Pliers, Needle-Nose, straight with cutters, 6-1/2"	
3.	5120-00-240-5328		

STOP

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-6a

SAFETY PROGRAM AND ACCIDENT PREVENTION

OBJECTIVE

Given a list of shop and plant safety hazards, write the method of eliminating each hazard in accordance with Air Force directives with no more than one instructor assist.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of items. You must each item correctly to receive a satisfactory rating.
2. You are authorized one instructor assist.
3. When you have completed the progress check, return it to your instructor.
4. If you have no questions, start your progress check.

DIRECTIONS

Complete the following questions pertaining to the safety program and accident prevention. Use SG AFS 54, 55, and 56, SAFETY, All Courses.

1. What is the general purpose of Air Force Safety Program?

2. What are the three (3) major causes of accidents in the Air Force?

__________________ STOP __________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-6b

SAFETY PROGRAM AND ACCIDENT PREVENTION

OBJECTIVE

Identify two basic facts about the Air Force Safety and Accident Prevention Program.

REFERENCE/MATERIAL/EQUIPMENT

SG AFS 54, 55, 56, entitled "SAFETY"

INSTRUCTIONS

1. This progress check consists of two items. You must answer each item correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

1. Solve each of the following problems correctly.

Using SG AFS 54, 55, and 56, SAFETY, All Courses, write the method of eliminating the safety hazards involved in and around a water or wastewater plant by listing the action(s) to take below.

1. What action(s) should be taken if vapors from fuels, oils and greases are entering and accumulating in the laboratory?

2. What action(s) should be taken when excessive tools are scattered about on the floor, workstands or any other places?

3. What type of clothing should NOT be worn when working with moving machinery parts?

4. How should heavy articles be carried by one person?

5. When mushroom heads develop on cold chisels, punches, hammers and other similar tools, what preventive safety procedures should be taken?

6. List the four essential aspects of behavior when working in a hazardous area.

STOP

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

CORROSION CONTROL

OBJECTIVE

Using information pertaining to corrosion, list the causes and types of corrosion. Five of eight must be correct.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of eight items. You must answer five items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

Complete the following questions pertaining to corrosion control.

1. What are four elements that cause corrosion?

   a.
   b.
   c.
   d.

2. What are the four types of corrosion?

   a.
   b.
   c.
   d.

____________________ STOP ____________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

CORROSION CONTROL

OBJECTIVE

Identify the three methods used to control the corrosion process.

REFERENCE/MATERIAL/EQUIPMENT

SG J3ABR56631 000-I-2 thru 10

INSTRUCTIONS

1. This progress check consists of three items. You must solve each item correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

1. Solve each of the following problems correctly.

Complete the following questions pertaining to the identification of each corrosion control process.

1. What step is used in the design of equipment to stop corrosion?

2. What two methods of cathodic protection are used to protect equipment?

3. What kind of protective coating is used to guard against corrosion?

________________ STOP ________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-8a

HAND AND SPECIAL TOOLS

OBJECTIVE

Given a list of tasks and a list of tools, select the tool that should be used to complete each task.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of five items. You must answer each item correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

Complete the following questions which pertain to the identification of handtools and what tool should be used to perform a specific job.

1. What tool is used to remove a hex head bot?

2. What tool should be used to remove a single slot screw?

3. What tool should be used to remove metal piping?

4. What tool should be used to cut metal wire?

5. What tools should be used to remove a recessed nut?

__________________ STOP __________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-8b

HAND AND SPECIAL TOOLS

OBJECTIVE

Given an electric grinder, a checklist and handtools, perform the required inspection and maintenance on the grinder with no more than one instructor assist.

REFERENCE/MATERIAL/EQUIPMENT

Preprinted Safety Checklist
Assorted Hand Tools

INSTRUCTIONS

1. This progress check consists of physically performing inspection and maintenance on an electric grinder in accordance with a checklist.
2. You are authorized one instructor assist.
3. You must perform each step in the checklist in order to receive a satisfactory rating.

DIRECTIONS

Attached is a checklist pertaining to inspection of the electric grinder. You must perform all actions on the checklist as your instructor grades you in the performance of each step.

1. Check for lose wiring.
2. Be sure that the grinder is properly secured to the floor, by four bolts.
3. Check the condition of the grinding wheel.
4. Adjust the safety guards to cover the spindle end.
5. Fill the temping bowl with water.
6. Adjust the work rest to support the tool.
7. Use a wire brush and clean grinding wheels.
8. Wear a safety shield and gloves, start electric grinder.
9. Allow one minute for wheel to run at full speed, check for vibrations.
10. Shut off grinder and unplug.

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-9a

OPERATION AND MAINTENANCE OF WATER AND WASTE-WATER TREATMENT SUPPORT EQUIPMENT

OBJECTIVE

Given four control devices, identify, inspect, and state the function and operation of each.

REFERENCE/MATERIAL/EQUIPMENT

SW J3ABR56631 000-I-2 thru 10
Pneumatic Control Device
Hydraulic Control Device
Mechanical Control Device
Electrical Control Device
Assorted Hand Tools

INSTRUCTIONS

1. This progress check will consist of inspecting and disassembling (if required) various control devices. You must determine the function and operation of each device with no instructor assistance.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS

You will be given four (4) control device numbers 1, 2, 3, and 4. You must inspect these devices and state the function and operation of each.

CONTROL DEVICE NUMBER	FUNCTION	OPERATION
1.		
2.		
3.		
4.		

________________ STOP ________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-9b

OBJECTIVE

Identify the purpose, operating features and operator maintenance requirements for air compressors. Three of the five must be correct.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of five items. You must answer three items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

Answer the following questions concerning air compressors.

1. What is the purpose of an air compressor?

2. Which component prevents the air storage tank from rupturing?

3. What two purposes do the air filters on air compressors serve?

4. Why must condensate be drained from air compressors daily?

5. In addition to draining condensate daily, what other operator maintenance must be performed on air compressors? (name two items)

__________________ STOP __________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-9c

OPERATION AND MAINTENANCE OF WATER AND WASTE-WATER TREATMENT SUPPORT EQUIPMENT

OBJECTIVE

Using AFR 91-26, list the purposes, types and inspection procedures for water storage tanks.

REFERENCE/MATERIAL/EQUIPMENT

AFR 91-26

INSTRUCTIONS

1. This progress check consists of fifteen items. You must answer each item correctly to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS

Using AFR 91-26, complete the following items pertaining to water storage tanks.

1. What are the three purposes of water storage tanks?

   a.

   b.

   c.

2. What are the three types of storage tanks?

   a.

   b.

   c.

3. List three inspection procedures for each type of storage tank listed in question #2.

   a.

      1.

      2.

      3.

   b.

      1.

      2.

      3.

c.

1.

2.

3.

STOP

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-9d

OPERATION AND MAINTENANCE OF WATER AND WASTE-WATER TREATMENT SUPPORT EQUIPMENT

OBJECTIVE

Given a set of incomplete statements about various valves, make written responses to identify each valve. Seven of the ten must be correct.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of 7 items. You must answer seven correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

Complete the following questions by making written responses to the incomplete statements pertaining to the identification of valves.

1. A _____________ valve is used for services requiring infrequent operation.
2. A _____________ valve is used for services requiring frequent operation.
3. A _____________ valve is used when there is a need to control the flow in only one direction.
4. A _____________ valve is used for services requiring sludge operations.
5. A disc that opens by water pressure and closes by gravity is used in a

   __________________ ____________________ ________________________.
6. Two variations of the gate valve are _______________ and _______________.
7. A _________________ valve is used to regulate flow.
8. A _________________ valve opens and closes with 1/4 of a turn.
9. A lift check valve can only be installed in a _______________ line.
10. The three general types of valve bonnets are ___________________, ________________, and ____________________.

_____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-9e

OPERATION AND MAINTENANCE OF WATER AND WASTE-WATER SUPPORT EQUIPMENT

OBJECTIVE

Given a check valve, disasemble, inspect, and reassemble the valve with no more than one instructor assist.

REFERENCE/MATERIAL/EQUIPMENT

Assorted Hand Tools

INSTRUCTIONS

1. This progress check consists of a performance item. You must accomplish each step correctly to receive a satisfactory rating.
2. Your instructor will grade you on step by step procedures.
3. If you have no questions, start your progress check.

DIRECTIONS

Follow the checklist below pertaining to the disassembly, inspection and reassembly of a check valve. The check valve will be furnished to you by the instructor. Use proper tools and be safety conscious of damaging valve parts.

CHECKLIST

Check Valve

Disassemble

1. Remove valve cover.
2. Loosen and remove hinge pin.
3. Remove the clapper assembly.

Inspection

4. Inspect clapper, clapper arm, cotter pin, threads and nut.
5. Inspect seat face and clapper ring for pitting, scale or scars to insure proper seating.

Reassemble

6. Place clapper assembly into valve case.

   NOTE: Insure correct placement of clapper; note direction.

7. Insert hinge pin into valve casing and through the clapper hinge.
8. Hand tighten hinge pin.
9. Install cover and hand tighten.

____________________ STOP ____________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-9f

OPERATION AND MAINTENANCE OF WATER AND WASTEWATER SUPPORT EQUIPMENT

OBJECTIVE

Using a gate valve on the pump trainer, remove and replace the valve packing to prevent water leakage with a maximum of two instructor assists.

REFERENCE/MATERIAL/EQUIPMENT

SW J3ABR56631 000-I-2 thru 10
Packing, Valve, Assorted Hand Tools

INSTRUCTIONS

1. This progress check consists of a performance item. You must perform each item correctly to receive a satisfactory rating.

2. Your instructor will grade you on step by step procedures.

3. You are authorized one instructor assist.

3. If you have no questions, start your progress check.

DIRECTIONS

1. Solve each of the following problems correctly.

Follow the checklist below pertaining to the removal and replacement of the packing around the stem of a gate valve. Follow the instructions given by the instructor and use the correct tools for cutting the packing and working on the valve. Be safety conscious when using sharp and pointed tools. Go to the pump trainer at the rear of the classroom and select one of two valves on the trainer to repack.

CHECKLIST

Repacking a Gate or Globe Valve

Disassemble

1. Open valve fully counterclockwise.

2. Remove wheel lock nut.

3. Remove hand wheel.

4. Remove packing nut.

5. Remove packing gland.

6. Remove all packing threads from stuffing box.

Inspection

7. Insure all packing is removed and stuffing box is clean and free of foreign matter.

8. Check valve stem and threads for excessive wear.

9. Check stuffing box and casing for cracks.

Replace packing

10. Fit packing around stem and cut to proper length. Cut packing on an angle so it will overlap.

11. While replacing the packing, stagger the packing around the valve stem according to the diagram.

Reassemble

12. Install packing gland.

13. Install packing nut and hand tighten.

14. Place hand wheel on valve stem.

15. Place wheel lock nut on valve stem and tighten lightly with wrench.

16. Close valve approximately half way.

17. Turn on main water valve.

18. Tighten packing nut until water stops leaking.

19. Close valve fully.

STOP

Before proceeding any further have the instructor check your answers and to confirm proper operation of the gate valve.

__________Instructor's initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-9g

OPERATION AND MAINTENANCE OF WATER AND WASTEWATER TREATMENT UNIT

OBJECTIVE

Using AFR 91-26 and information pertaining to electric motors and power connectors, list the operational maintenance requirement for motors and connectors.

REFERENCE/MATERIAL/EQUIPMENT

SW J3ABR56631 000-I-2 thru 10
AFR 91-26

INSTRUCTIONS

1. This progress check consists of sixteen items. You must complete each item correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

List the operational checks and maintenance requirements for motors and power connectors. You may use AFR 91-26.

Piece of Equipment	Operational Checks	Maintenance
1. Motors	a.	a.
	b.	b.
	c.	c.
2. Belt drives	a.	a.
	b.	b.
3. Chain drives	a.	a.
	b.	b.
4. Couplings	a.	a.

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Sheppard AFB, Texas

PC J3ABR56631 000-I-9h

OPERATION AND MAINTENANCE OF WATER AND WASTE-WATER SUPPORT EQUIPMENT

OBJECTIVE

Given information pertaining to chemical feeders, identify the three types of chemical feeders by completing written statements.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of three items. You must solve each item correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

1. Solve each of the following problems correctly.

Identify the three types of chemical feeders by completing the statements in Column A. Choose your answers from Column B. Words in Column B may be used once, twice or not at all.

COLUMN A

1. A _______________ chemical feeder displaces a definite weight of present volume of chemical.
2. A _______________ chemical feeder injects a chemical solution into the water supply.
3. A _______________ chemical feeder may be either vacuum or direct feed.

COLUMN B

Solution
Volute
Gas
Dry

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Sheppard AFB, Texas

PC J3ABR56631 000-I-91

OPERATION AND MAINTENANCE OF WATER AND WASTEWATER SUPPORT EQUIPMENT

OBJECTIVE

REFERENCE/MATERIAL/EQUIPMENT

Assorted Hand Tools
Dry Chemical Feeder
Gas Feeder
Solution Feeder

INSTRUCTIONS

1. This progress check consists of three parts. You must correctly perform all items with a maximum of five instructor assists to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS

PROGRESS CHECK I-91 (1)

Student's Name ______________

INSTRUCTIONS

Follow the checklist below pertaining to the disassembly, inspection and reassembly of a chemical solution feeder. The feeder is located on the pump trainer at the rear of the classroom. Use the proper tools and be safety conscious; assistance will be given by the instructor.

CHECKLIST

Chemical Solution Feeder

DISASSEMBLE UNIT

1. Remove suction and discharge tubing
2. Remove poppet valves
3. Remove four (4) screws and pump head
4. Remove flexible diaphragm
5. Remove rubber boot

INSPECT COMPONENTS

6. Inspect for cracks and tears on rubber boots and flexible diaphragm.
7. Inspect for cracks on plastic pump head.
8. Check the O-ring for worn areas and cracks.
9. Insure chemical passage channels are clear.
10. Insure poppet valves are free from scale or chemical buildup - insure valves seat properly.
11. Check to insure chemical feeder lines are unobstructed.

REASSEMBLE UNIT

12. Before installing feeder parts, turn feeder control knob to #10 feed rate.
13. Install rubber boot on pump shank.
14. Install rubber diaphragm.
15. Install plastic pump head with four (4) screws.
16. Install suction and discharge tubing and poppet valves.
17. Prime the chemical feeder.
18. Operate the chemical feeder and pump a liquid through the feeder lines.
19. Adjust control knob to #6 feed rate.

STOP

At this time have the instructor confirm proper operation of the chemical feeder and that you have completed this objective.

PROGRESS CHECK I-91 (2)

Student's Name ________________

Instructions

Follow the checklist below pertaining to the disassembly, inspection and reassembly of a dry chemical feeder.

Checklist

Dry Chemical Feeder

Disassemble Unit

Inspect Components

Reassemble Unit

_____________ STOP _____________

At this time have the instructor confirm proper operation of the chemical feeder and that you have completed this objective.

Turn feeder off; clean area, store tools.

INSTRUCTIONS

Follow the checklist below pertaining to the disassembly, inspection and reassembly of a gas chemical feeder.

CHLORINE TRAINER PROCEDURES CHECKLIST

Chlorine Gas Room

1. Smell for chlorine gas odor.
2. Visually check feed controller.
3. Check safety chains.
4. Cylinder weight is __________ lbs.

Exchange chlorine cylinder

1. Secure scale.
2. Close main chlorine cylinder valve.
3. Wait until gas dissipates within feed controller.
*4. Disconnect plastic feed and vent lines to chlorinator.
*5. Disconnect chlorinator lock screw.
6. Remove chlorinator unit.
7. Install valve cap.
8. Install cylinder cap.
9. Unfasten safety chain.
*10. Remove empty cylinder from scale, set aside.
*11. Place full cylinder on scale.
12. Check cylinder valve position.
13. Secure safety chain.
14. Remove safety chain.
15. Insure that main cylinder valve is closed.
16. Remove valve cap and gasket.

Attach chlorinator to chlorine cylinder

1. Remove old gasket from chlorinator and replace it with new gasket.
2. Clean stem and orifice area of chlorinator.
3. Mount chlorinator and secure locknut and bolt.
*4. Secure two (2) plastic feed and vent lines to chlorinator.
5. Open chlorine cylinder valve.
6. Set switch on chlorinator from "no gas" to "operate".
7. Check sight glass on feed controller to insure small black ball is operational, indicating feed rate.
8. Check for chlorine leaks.
9. Adjust feed control.
10. Tag chlorine cylinder.
11. Weight of full cylinder is ________ lbs.

__________________ STOP ________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-9j

OPERATION AND MAINTENANCE OF WATER AND WASTE-WATER SUPPORT EQUIPMENT

OBJECTIVE

Given information pertaining to different types of measuring devices, write the function and application of each and record a meter reading. Five of seven must be correct.

REFERENCE/MATERIAL/EQUIPMENT

SG J3ABR56631 000-1 thru 10

INSTRUCTIONS

1. This progress check consists of seven items. You must correctly answer five items to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

List the various water meter and measuring devices and state the operating function of each device. State the purpose or application of each unit. Go to the pump trainer at the rear of the classroom and record your water meter readings.

TYPES OF MEASURING DEVICES	APPLICATION	FUNCTION
1. Positive displacement		
2. Current Velocity (turbine)		
3. Compound		
4. Venturi		
5. Orifice Meter		
6. Parshall Flume		

7. Reading taken from meter _________

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Sheppard AFB, Texas

PC J3ABR56631 000-I-9k

OPERATION AND MAINTENANCE OF WATER AND WASTE-WATER SUPPORT EQUIPMENT

OBJECTIVE

Given a water meter, disassemble, inspect and reassemble the meter using a checklist or manufacturer's brochure with no more than one instructor assist.

REFERENCE/MATERIAL/EQUIPMENT

Manufacturer's Brochure, Water Meter, Assorted Hand Tools, Checklist

INSTRUCTIONS

1. This progress check consists of a performance item. You must correctly perform all items to receive a satisfactory rating.
2. You are authorized one instructor assist.
3. When you have completed the progress check, return it to your instructor.
4. If you have no questions, start your progress check.

DIRECTIONS

Follow the checklist below pertaining to the disassembly, inspection and reassembly of a water meter. The meter and manufacturer's brochure will be furnished to you by the instructor. Use the proper tools and be conscious of all small, delicate meter parts. Practice tool safety.

CHECKLIST

Water Meter

Disassemble Unit

1. Loosen seal screw on register assembly.
2. Remove six housing bolts.
3. Remove housing.
4. Remove plastic retainers strap —— CAUTION: DO NOT use excessive pulling force, plastic strap will tear!
5. Remove meter chamber unit and plastic screen.
6. Disassemble meter chamber —— CAUTION: Small, delicate parts require care when disassembling.
    a. Separate chamber halfs -
        1 DO NOT DISASSEMBLE TOP HALF.
        2 DISASSEMBLE BOTTOM HALF - ONLY.
    b. Remove nutating disc —— CAUTION: Small parts.
    c. Remove thrust roller and insert.

Inspection

1. Check for worn, cracked or swollen disc.
2. Check for cracked or broken meter parts.
3. Check for scale and algae - remove if necessary.
4. Inspect plastic screen, clean if required.
5. Insure inlet and outlet passage ways are clean of scale and clear of foreign matter.
6. Check rubber seal and gasket for wear and cracks.
7. Check meter bolts for corrosion and stripped threads - replace if necessary.
8. Insure dial recorder is operational; DO NOT disassemble dial unit.

Reassemble Unit

1. Place thrust roller and thrust insert into respective components.
2. Insert nutating disc into bottom half of meter chamber, aligning the thrust roller with the thrust insert.
3. Place the top disc chamber onto the bottom disc chamber aligning the two (2) chamber guides - insure the outlet ports are matched together, side-by-side.
4. Holding entire chamber together, check for freedom of disc movement by turning the drive mechanism (magnet).
5. Install O'ring gasket on meter case.
6. Install plastic screen on inlet side of meter case.
7. Insert disc chamber into bottom of meter case, using the guide post for proper alignment.
8. Insert plastic chamber retaining strap —— CAUTION: DO NOT use excessive force, plastic will tear!
9. Place meter housing top on housing base, aligning arrow with inlet side of meter.
10. Insert six (6) bolts and washers.
11. Hand tighten meter bolts. DO NOT USE A WRENCH FOR TIGHTENING BOLTS!
12. Place meter dial and register on meter case.
13. Hand tighten seal screw.

———————— STOP ————————

At this time have the instructor confirm proper operation of the meter and that you have completed this performance objective.

__________Instructor's initials

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PC J3ABR56631 000-I-91

OPERATION AND MAINTENANCE OF WATER AND WASTE-WATER SUPPORT EQUIPMENT

OBJECTIVE

Monitor the operation of selected backflow preventers and list the four methoods of backflow prevention with no more than one instructor assist.

REFERENCE/MATERIAL/EQUIPMENT

3 Backflow Preventer Devices
Assorted Hand Tools

INSTRUCTIONS

1. This progress check consists of two parts. Part I requires performance while Part II is a written exam. All items must be performed satisfactorily and all written responses must be correct.

2. You are authorized a total of one instructor assist on the entire combined progress check.

3. When you have completed the progress check, return it to your instructor.

DIRECTIONS

PART I. Your instructor will provide you with the location of three permanently installed, operating backflow preventors. Monitor the operation.

LOCATION

1. Room 30, Bldg 1921

   a. Operate flow valve in chemical mixing tank.

   b. Lift float rapidly to stop the flow of water.

   c. Monitor backflow device to determine if backpressure is vented.

2. Outside lawn sprinkler
(between fence and storage
shed, west side, plumbing
area)

   a. Open main controlling valve to activate sprinkler system.

   b. Monitor operation to determine if poppet is operating.

3. Room 46, Bldg 1921

   a. Monitor to determine if backflow preventer is in operation.

   b. Determine flow direction.

PART II. List the four types of backflow preventers.

1.

2.

3.

4.

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Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-9m

OPERATION AND MAINTENANCE OF WATER AND WASTEWATER SUPPORT EQUIPMENT

OBJECTIVE

Given four types of backflow preventer malfunctions, select the maintenance required to correct the malfunction. Three of four must be correct.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of four items. You must correctly answer three items to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

Below are listed four backflow preventor malfunctions and a corresponding list of maintenance actions required on these devices. Match the applicable maintenance action with the backflow preventor requiring that type of maintenance. Each maintenance action may be used once, more than once or not at all.

_____ 1. The spring loaded check valve failed to close during testing.

_____ 2. The distance from the delivery line to the receiving line looks questionable on an air gap backflow preventor.

_____ 3. The relief valve between the check valves on an RP device leaks.

_____ 4. The poppet on an atmospheric vacuum breaker has become stuck due to continuous pressure.

a. Insure separation between potable and non-potable water is 2 times the pipe diameter.

b. Replace with a pressure vacuum breaker.

c. Remove and clean the diaphragm.

d. Replace springs.

e. Replace the poppet.

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PC J3ABR56631 000-I-9n

OPERATION AND MAINTENANCE OF WATER AND WASTE-WATER SUPPORT EQUIPMENT

OBJECTIVE

Using AFR 91-26, list three operational services which are common to standby engines.

REFERENCE/MATERIAL/EQUIPMENT

AFR 91-26

INSTRUCTIONS

1. This progress check consists of three items. You must correctly answer all items to receive a satisfactory rating.
2. You may use AFR 91-26.
3. When you have completed the progress check, return it to your instructor.
4. If you have no questions, start your progress check.

DIRECTIONS

Below are three (3) phases of the operation of a standby engine, list three services essential in each operation. Use AFR 91-26 to aid you.

1. Preoperation	Service
2. During operation	
3. Post-operation	

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Sheppard AFB, Texas

PC J3ABR56631 000-I-9o

OPERATION AND MAINTENANCE OF WATER AND WASTEWATER SUPPORT EQUIPMENT

OBJECTIVE

Given a list of pump types and a list of pump characteristics, match the pump type to its characteristic. Three of the five answers must be correct.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of five items. You must correctly answer three items to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS

Match the pump to it's characteristic. Match the letter column to the numbered column by entering the letter in space in front of the number.

Pump Type	Characteristic
1. Centrifugal	a. No moving parts in the water
2. Rotary	b. Separates the liquid from the moving parts
3. Piston	c. May be single or double acting
4. Air Lift	d. Used for priming larger pumps
5. Diaphragm	e. Disc with vanes curved backward from the direction of rotation

OPERATION AND MAINTENANCE OF WATER AND WASTE-WATER SUPPORT EQUIPMENT

OBJECTIVE

Using the sewage lift station trainer and working as a team, monitor/operate the trainer in accordance with standard operating procedures with no more than two instructor assists.

REFERENCE/MATERIAL/EQUIPMENT

None

INSTRUCTIONS

1. This progress check consists of a performance item. You must correctly perform each step to receive a satisfactory rating.

2. You will be a member in a team of three.

3. When you have completed the progress check, return it to your instructor.

4. You are authorized one instructor assist.

5. If you have no questions, start your progress check.

INSTRUCTION

Follow the checklist for the operation of sewage lift trainer. The instructor will take you to the trainer. You will operate this trainer as a member of a team consisting of no more than three.

CHECKLIST

1. Safety

   a. Remove all jewelry.
   b. Good housekeeping.
   c. Disconnect power before filling.

2. Prepare for operation

   a. Close valves 1 and 2
   b. Remove filler plug 3
   c. Fill holding tank
   d. Move motor switches to automatic
   e. Turn main breaker to off
   f. Open valve 1
   g. Move main breaker to on

3. Monitor the operation

   a. Check motor during operation for overheating
   b. Check control devices
   c. Check for leaks
   d. Check alarm
   e. Take pressure gauge reading
   f. Alternate pumps
   g. Check packing leakage

4. Perform normal shutdown

    a. Turn breakers to off
    b. Drain all equipment

5. Perform emergency shutdown

    a. Move main breaker to off
    b. Disconenct main power cable
    c. Drain all equipment
    d. Notify the proper personnel

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Sheppard AFB, Texas

OPERATION AND MAINTENANCE OF WATER AND WASTEWATER SUPPORT EQUIPMENT

OBJECTIVE

Using the sewage lift station trainer and working as a team, perform operator inspection and maintenance on the trainer in accordance with checklist, with no more than two instructor assists.

REFERENCE/MATERIAL/EQUIPMENT

Checklist/PC J3ABRE56631 000-1 thru 10
Assorted Hand Tools

INSTRUCTIONS

1. This progress check consists of a performance item. You must correctly perform all items to receive a satisfactory rating.

2. You will be authorized two instructor assists.

3. When you have completed the progress check, return it to your instructor.

4. If you have no questions, start your progress check.

DIRECTIONS

Follow the checklist for maintaining the sewage lift trainer. The instructor will take you to the trainer. You will maintain this trainer as a member of a team not to exceed four students.

CHECKLIST

1. Safety
    - a. Remove all jewelry
    - b. Turn off power
2. Preoperation inspection
    - a. Inspect electrical wiring
    - b. Inspect control devices
    - c. Inspect coupling
    - d. Loose bolts
    - e. Check all valves
    - f. Inspect electrical control panel
    - g. Inspect for corrosion
    - h. Check grease fittings
    - i. Check all nomenclatures
3. Maintenance
    - a. Lubricate according to manufacturer's manual
    - b. Replace packing
    - d. Unplug impeller

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Sheppard AFB, Texas

PC J3ABR56631 000-I 9r

OPERATION AND MAINTENANCE OF WATER AND WASTEWATER SUPPORT EQUIPMENT

OBJECTIVE

During a field trip to the base water and wastewater facilities, use a checklist to monitor and inspect the support equipment. Student's checklist must correspond to 60% of instructors evaluation of the facility.

REFERENCE/MATERIAL/EQUIPMENT

Study Guide J3ABR56631 000-I-1 thru 10

INSTRUCTIONS

1. This progress check consists of twenty items concerning the monitoring and inspection of Water/Wastewater support equipment which is permanently installed in the Base facilities. Your instructor will select particular components for you to monitor and/or inspect. You will note your comments in the "Condition Noted" and "Action" column. Your instructor will be noting his comments also. Your completed progress check must correspond to 60% of the instructors evaluation on the selected item.

2. You may refer to your notes and SG J3ABR56631 000-I-1 thru 10.

3. If you have no questions, begin your progress check.

DIRECTIONS

During the field trip to the base water and wastewater facilities,

Attached are two equipment listings, one pertains to the water facility while the other pertains to the wastewater facility. Insure you are using the correct checklist as your instructor assigns the particular component you are to monitor/inspect.

PROGRESS CHECK I-9r

Student's Name ________________

INSTRUCTION

During the field trip to the base water and wastewater facilities, note the equipment listed on the checklist. Inspect for any deficiencies and write the recommended actions to take to correct each deficiency. Provided is an equipment checklist for each plant facility. Both checklists must be completed prior to beginning the next criterion objective. C.O. 9h(3), STS: 11b(3) (a) chemical feeders, gas continued.

CHECKLIST

Water Pumping Facility

Equipment Listing	Condition Noted	Actions
1. Pumps -		
2. Valves -		
3. Chemical Feeders -		
4. Measuring Devices -		
5. Control Devices -		
6. Standby Engines -		
7. Electric Motors -		
8. Tanks -		
9. Drive Devices -		
10. Safety Precautions -		

CHECKLIST

Wastewater Treatment Facility

Equipment Listing	Condition Noted	Actions
1. Pumps -		
2. Valves -		
3. Chemical Feeders -		
4. Measuring Device -		
5. Control Devices -		
6. Standby Engines -		
7. Electric Motors -		
8. Tanks -		
9. Drive Devices -		
10. Safety Precautions -		

____________________ STOP ____________________

Before proceeding any further, have the instructor check your work.

____________Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-I-10a

PUMP AND EQUIPMENT MAINTENANCE

OBJECTIVE

Given a centrifugal pump and working as a team, disassemble, inspect and reassemble the pump with no more than two instructor assists.

REFERENCE/MATERIAL/EQUIPMENT

SW J3ABR56631 000-I-1 thru 10
Assorted Handtools
Pump Packing
Gasket Material

INSTRUCTIONS

1. This progress check consists of a performance item. You must follow the step by step procedures in this progress check in order to obtain a satisfactory rating.

2. You are authorized two instructor assists in the performance of this progress check.

3. Anytime there is danger to either you, other students, or the equipment, your instructor will stop your performance. This constitutes an instructor assist.

4. When you have completed this progress check, report to your instructor.

5. If there are no questions, start your progress check.

DIRECTIONS

Following is the SOP for the disassembly and reassembly of pumps. Follow the instructions given by the instructor and use the correct tools for disassembly and reassembly of the pump. Use proper safety procedures while working on pump. Go to the pump given to you by the instructor.

PUMP MAINTENANCE

SOP

Disassembly

1. Remove packing gland bolts
2. Remove packing gland
3. Remove packing and lanter ring from stuffing box

NOTE: Remove lanter ring with a piece of wire

4. Remove volute housing
5. Remove impeller bolt with washer, then impeller
6. Remove key way
7. Remove stuffing box housing off the shaft
8. Remove shaft sleeve, lanter ring, and deflector
9. Remove bearing cover
10. Remove shaft from pump housing

NOTE: Use plastic mallet, tap lightly on impeller end until shaft comes out.

Inspection

1. Inspect all parts of pump for wear and tear
2. Clean all parts of pump

Reassembly

1. Place O'ring on shaft with shaft sleeve
2. Install shaft into pump housing
3. Install deflector and lanter ring on shaft
4. Place stuffing box housing on shaft and bolts into place
5. Install the bearing cover on and bolts
6. Install impeller on end of shaft with bolt and washer
7. Install volute housing around impeller with gaskets, bolt to main body
8. Let your instructor check pump before installing pump to electric motor
9. After pump is installed on pump base with electric motor, and coupling is aligned up, continue on
10. Install packing into stuffing box, cutting it the proper size
11. Two pieces of packing into stuffing box first
12. Place lanter ring into stuffing box
13. Place more packing into stuffing box
14. Place packing gland with nuts and bolts
15. Rotate shaft to detect binding

———— STOP ————

Before proceeding any further have the instructor check your pump for correct reassembly and operation according to the checklist and prior instructions.

__________Instructor's initials

3770 Technical Training Group
Civil Engineering Training
Sheppard AFB, Texas

PC J3ABR56631 000-I-10b

PUMP AND EQUIPMENT MAINTENANCE

OBJECTIVE

Using the water (pump) trainer and working as a team, remove, dissassemble, inspect reassemble and install the pump to its operating condition with no more than two instructor assists.

REFERENCE/MATERIAL/EQUIPMENT

SW J3ABR56631 000-I-1 thru 10
Assorter Handtools
Pump Packing
Gasket Material

INSTRUCTIONS

1. This progress check consists of a performance item. You must follow the step by step procedures in this progress check in order to obtain a satisfactory rating.

2. You are authorized two instructor assists in the performance of this progress check.

3. Anytime there is danger to either you, other students or the equipment, your instructor will stop your performance. This constitutes an instructor assist.

4. When you have completed this progress check, report to your instructor.

5. If you have no questions, begin your progress check.

DIRECTIONS

Following is the SOP for removal of a pump from the trainer, disassembly, inspection, reassembly and installing pump on the trainer. Follow the instructions given by the instructor, and use the correct tools with safety procedures while working on pump. Go to the back of room to the pump trainer given to you by your instructor.

REMOVAL OF PUMP FROM TRAINER

Use the below procedures for disassembling a centrigual pump.

NOTE: Remove jewelry before beginning this exercise.

1. Remove the pressure gauge and store under the trainer.

2. Remove the coupling cover.

3. Loosen the one set screw on the coupling on pump side only.

4. Break loose both the suction and discharge unions.

5. Remove both the suction and discharge unions - use the wrenches provided, metal slivers hurt!

6. Remove the four pump hold down bolts, making sure you hold on to pump. The pump is top heavy.

7. Pull the pump forward and off stand, leave the key on the shaft of the electric motor.

8. Take the pump to the drain on the floor, tip suction end forward and drain, if necessary.

9. Take the pump over to the worktable.

PUMP MAINTENANCE

SOP

Disassembly

1. Remove packing gland bolts
2. Remove packing gland
3. Remove packing and lanter ring from stuffing box

NOTE: Remove lanter ring with a piece of wire

4. Remove volute housing
5. Remove impeller bolt with washer, then impeller
6. Remove key way
7. Remove stuffing box housing off the shaft
8. Remove shaft sleeve, lanter ring, and deflector
9. Remove bearing cover
10. Remove shaft from pump housing

NOTE: Use plastic mallet, tap lightly on impeller end until shaft comes out.

Inspection

1. Inspect all parts of pump for wear and tear
2. Clean all parts of pump

Reassembly

1. Place O'ring on shaft with shaft sleeve
2. Install shaft into pump housing
3. Install deflector and lanter ring on shaft
4. Place stuffing box housing on shaft and bolt into place
5. Install the bearing cover and bolts
6. Install impeller on end of shaft with bolt and washer
7. Install volute housing around impeller with gaskets, bolt to main body
8. Let your instructor check pump before installing pump to electric motor
9. After pump is installed on pump base with electric motor, and coupling is aligned, continue on
10. Install packing into stuffing box, cutting it to the proper size
11. Two pieces of packing into stuffing box first
12. Place lanter ring into stuffing box
13. Place more packing into stuffing box
14. Place packing gland with nuts and bolts
15. Rotate shaft to detect binding

INSTALL PUMP ON TRAINER

Use the below procedures to install a centrifugal pump.

1. Put coupling on pump shaft with key inserted.
2. Connect coupling but do not align it or tighten set screw.
3. Put pump hold down bolts on finger tight.
4. Connect both suction and discharge elbows and line them up with their correct pipes, do not connect unions at this time.
5. Align coupling using a straight edge (it will be checked when you are ready).
6. This step requires two people. One person connects and tightens union, the other person will keep the straight edge on the coupling to recheck the alignment.
7. Tighten the set screw on the coupling.
8. Install the coupling guard.
9. Install the pressure gage.
10. Open suction valve slightly and close discharge valve and prime the pump using the top petcock on the pump.
11. After priming - open the suction valve all the way.
12. Turn on the power.
13. Open the discharge valve slowly about 5 or 6 slow turns and watch the pressure gauge for cavitation (lost pressure).
14. If pressure is steady, open the valve all the way. If not, reprime the pump.
15. Grease the two fittings on the pump - about 5 squirts, wipe fitting before and after greasing.
16. Adjust packing nut for proper leakage.
17. Keep pump running until you are told to shut it down.

______________ STOP ______________

At this time have the instructor confirm proper operation of the pump and that you have completed this objective.

___________Instructor's initials

STUDY GUIDE/WORKBOOK
J3ABR56631 000-II-1 thru 7

Technical Training

Environmental Support Specialist

WATER AND WASTEWATER ANALYSIS

June 1986

3700 TECHNICAL TRAINING WING
3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

Designed for ATC Course Use
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Supersedes SGs J3ABR56631-II-1 thru 7, June 1984

3770 Technical Training Group
(Civil Engineering Training)
Sheppard AFB, Texas

RELATED MATHEMATICS

OBJECTIVES

Solve problems in addition, subtraction, multiplication and division of whole numbers.

Solve problems in addition, subtraction, multiplication and division of decimals.

Solve problems in addition, subtraction, multiplication and division of fractions.

Given the formulas, dimensions, and a geometric figure of a square, rectangle and circle, compute the area of each.

Given the formulas, dimensions, and a geometric figure of a square, rectangle and cylinder, compute the volume of each.

Given problems pertaining to a typical water supply system, and a maximum of three instructor assists, follow the correct procedures to complete each problem.

Given the temperature conversion formulas, convert temperatures between the metric and English systems.

INTRODUCTION

Many parts of your job as an Environmental Support Specialist require the use of math. The purpose of this section is to review some math skills you have now, and develop some new skills which you will need on the job.

WHOLE NUMBERS

Whole numbers are any of the natural numbers, the negatives of these numbers, or zero. The numbers -6, 12, 0 are all examples of whole numbers. If you are a little rusty on addition, subtraction, multiplication and division of whole numbers, you should do some extra practice.

Exercise II-1-a

Instructions: Solve the following problems

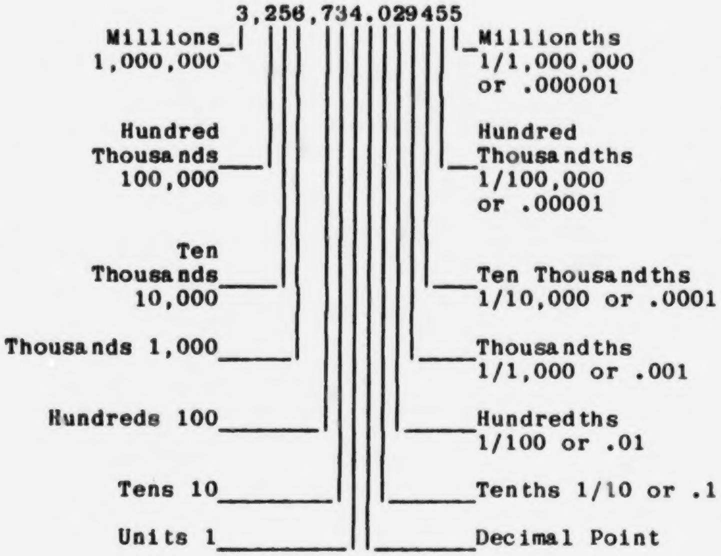
67856		1059	23 / 12,558
22851	2,498	X 218	
44238	- 1,539		
+ 97156			

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

DECIMALS

A decimal is a fraction which has a denominator that is a power of 10 (10, 100, 1000, etc.), and is written by using a decimal point (period). That is, two tenths (2/10) is written .2, and sixty-two hundreths (62/100) is written .62. These are read the same as common fractions, that is .6 is six tenths, and .47 is forty-seven hundredths. See Figure 1. Working with decimals is usually easier than working with fractions, but certain rules must be followed.



3,256,734.029455
Millions 1,000,000
Hundred Thousands 100,000
Ten Thousands 10,000
Thousands 1,000
Hundreds 100
Tens 10
Units 1
Millionths 1/1,000,000 or .000001
Hundred Thousandths 1/100,000 or .00001
Ten Thousandths 1/10,000 or .0001
Thousandths 1/1,000 or .001
Hundredths 1/100 or .01
Tenths 1/10 or .1
Decimal Point

FIGURE 1

When we add or subtract decimals the decimal points must be "lined up." For example:

$$\begin{array}{r} 42.6 \\ +\ 8.43 \\ \hline 51.03 \end{array} \qquad\qquad \begin{array}{r} 16.05 \\ -\ 10.6 \\ \hline 5.45 \end{array}$$

We add or subtract the numbers in the normal way. We start from the right and borrow or carry as needed, but the decimal point acts as our reference point. The first digit to the right of the decimal point in one number is combined with the first digit to the right of the decimal point in the other number and so on. If no digit is written in a position we may assume that digit to be zero. 42.6 is assumed to be 42.60, and 10.6 is assumed to be 10.60. Notice that 42.60 is the same as 42.6. You may add as many zeros as you like to the right of the last digit to the right of the decimal point without changing the value of the number.

When multiplying numbers which contain decimal points, the answer must have as many digits to the right of the decimal point as there were digits to the right of the decimal point in both of the original numbers. For example if .02 and .5 were multiplied the answer should have the three digits to the right of the decimal point. The answer is .010. The last zero can be dropped without changing the number, that is .01 is the same as .010. This rule is used in these problems:

$$\begin{array}{r} 2.61 \\ \text{X}\ \ .43 \\ \hline 7\ 83 \\ 1044\ \ \\ \hline 1.1223 \end{array} \qquad\qquad \begin{array}{r} 10.2 \\ \text{X}\ \ \ 5 \\ \hline 51.0 \end{array} \qquad\qquad \begin{array}{r} 8.34 \\ \text{X}\ 7.5\ \\ \hline 4170 \\ 5838\ \ \\ \hline 62.550 \end{array}$$

To divide numbers which contain decimal points you must move the decimal point of the divisor (what you are dividing by) to the right of all the digits which are not zero. For example in 2.54 the decimal point must be moved to the right of the 4 (254.). In 2.10 the decimal point must be moved to the right of the 1 (21.0). If we move the decimal point to the right in the divisor only, we will not get the same answer to the problem. To correct for this, the decimal point is moved in the other number (dividend) as well. The decimal point must be moved the same distance and direction in both divisor and dividend. Look at the problem 2.10 ÷ 2.54. The symbol ÷ is read "divided by." So 2.54 is the divisor and 2.10 the dividend. The decimal point must be moved to the right two digits to make the divisor 254.. So the decimal point must be moved two places to the right in the dividend as well. The problem we now read as 210. ÷ 254.. This problem has the same answer as the problem we started with.

Perhaps you have noticed that 254 is larger than 210. This means that 254 goes into 210 less than once. It also means that we will need to add zeros to the right of the decimal point in 210. to make our calculations. The decimal point in the answer goes directly above the decimal point in the dividend, after it has been moved.

```
          .8267
    254./210.0000
         2032
          680
          508
          1720
          1524
           1960
           1778
            182
```

In the problem we have just done we could have continued to add zeros to 210. and continued to get more digits in our answer but this is not a practical way to spend a lifetime. So if we want to stop and round off our answer to the thousandths position (.827) the 6 is changed to a 7 because the next digit to the right (the first one we dropped) was larger than five. If the first dropped digit is smaller than five, no changes are made in the digits which remain. If the first dropped digit is a five the digit to its left is increased only if it is an odd digit. So, .25 is rounded to .2, and .35 is rounded to .4. When we multiplied 2.61 by .43 our answer was 1.1223, this can be rounded off to 1.22. The accuracy of the equipment used to obtain the original number determines where the answer should be rounded off.

In some cases you may need to convert a decimal to a common fraction. You can do this by recalling what a decimal is. Three tenths may be written .3 or 3/10. Twenty-five hundredths, .25, may be written 25/100 and reduced to 1/4.

Exercise II-1-b

Instructions: Solve these decimal problems using either addition, subtraction, multiplication or division.

45.56 + 31.87 + 13.89 + .16 = ____________________

38.34 + 8.347 + .2984 + 1.2 = ____________________

387.09 - 283.51 = ____________ 548.9 - 1.384 = ____________

```
   0.0073              7.85
X     5.4            X 6.66
```

.58 / 259.   2.5 / .625

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

COMMON FRACTIONS

A fraction is a ratio of two whole numbers (2/3, 1/2, 3/4). A fraction can be thought of as showing a part of a whole. The number on the bottom of the fraction (the denominator) shows how many equal parts the whole is divided into, and the top number (the numerator) shows how many of these parts we are talking about. A fraction can also be thought of as a division problem; 2/3 is the same as 2÷3. In this case the numerator is 2 and the denominator is 3.

We will use three types of fractions: proper, improper and mixed. In a proper fraction the numerator (number on the top) is less than the denominator. Proper fractions are always less than one. Some examples are 1/2, 2/5 and 3/10. Improper fractions may be written as a whole number or a whole number and proper fraction. 5/2 is the same as 2 1/2 and 10/3 is the same as 3 1/3. These are called mixed numbers. 2/1 is the same as 2 which is not a mixed number. So we cannot say all improper fractions may be written as mixed numbers.

You must be able to change improper fractions to mixed numbers, and mixed numbers to improper fractions. To change an improper fraction to a mixed number, divide the numerator by the denominator. The answer to this division is the whole number. The remainder is the numerator of the fractional part. The denominator stays the same. To change 7/5 to a mixed number divide 7 by 5. You get 1 with a remainder of 2. So 7/5 is the same as 1 2/5. To change a mixed number to an improper fraction, multiply the denominator by the whole number, then add the result to the numerator of the fraction. This gives you the numerator of the improper fraction. The denominator stays the same. To change 2 1/6 to an improper fraction multiply 2 times 6 to get 12. Then add 1 to get 13. So 2 1/6 is the same as 13/6.

To add or subtract fractions they must first have the same (a common) denominator. After the fractions are written with common denominators the numerators can be added or subtracted. For example 1/3 + 1/3 = 2/3 and 5/7 - 1/7 = 4/7. To change fractions like 1/3 and 1/2 with common denominators, you must use the fact that the numerator and denominator of a fraction may be multiplied or divided by the same number. For example 2/3 is the same as 4/6 or 6/9. If the numerator and denominator of 1/3 are both multiplied by 2, 2/6 is obtained. If we use three as a multiplier 1/2 becomes 3/6. So 1/3 + 1/2 is the same as 2/6 + 3/6. Now all we do is add 2 and 3, and the answer is 5/6. You will save yourself work by using the lowest common denominator you can find. That is to add 1/4 and 1/6, use 12, not 24 or 36, as a common denominator. Like this:

$$\frac{1}{4} + \frac{1}{6} = \frac{3}{12} + \frac{2}{12} = \frac{5}{12}$$

To multiply fractions, the numerators are multiplied to find the numerator of the answer. The denominators are multiplied to find the denominator of the answer.

For example: $\frac{2}{3} \times \frac{4}{5} = \frac{8}{15}$

To divide fractions we change the division problem into a multiplication problem by taking the reciprocal of the divisor. The reciprocal of a fraction is found by switching the numerator and denominator. Every number other than zero has a reciprocal. Whole numbers or mixed numbers must first be written as improper fractions, then their numerators and denominators are interchanged. The reciprocal of 2/3 is 3/2. The reciprocal of 6 is 1/6, and the reciprocal of 2 1/2 (5/2) is 2/5. Multiplying by the reciprocal has exactly the opposite effect of multiplying by the original number. Multiplying by the reciprocal has the same effect as dividing. This fact is used to divide fractions. We change 2/3 ÷ 2 to 2/3 x 1/2 which equals 2/6 or 1/3. Notice we did two offsetting things: (1) we changed from division to multiplication, and (2) we used the reciprocal of 2 which is 1/2.

To convert common fractions to decimals you do the division indicated by the fraction. 3/8 means 3 divided by 8 so:

```
     .375
 8 /3.000
    2 4
      60
      56
      40
```

shows 3/8 = .375.

Remember we said a fraction is a division problem.

Exercise II-1-c

<u>Instructions</u>: Solve the following fraction problems using either addition, subtraction, multiplication or division.

PART I

1. 3/4 + 1/2 = ____________
2. 8/15 + 3/5 = ____________
3. 1/64 + 3/8 = ____________
4. 1/6 + 2/9 = ____________
5. 3/7 + 1/21 = ____________
6. 1/2 - 1/3 = ____________
7. 3/4 - 2/3 = ____________
8. 2 7/8 - 1 1/6 = ____________
9. 28 1/2 - 19 1/4 = ____________
10. 1 1/4 - 3/4 = ____________

PART II

1. 1/3 X 2/3 = ____________
2. 1 5/6 X 13 = ____________
3. 10 1/2 X 3 1/3 = ____________
4. 7/12 X 3/5 = ____________
5. 9 1/2 X 3 2/5 = ____________
6. 3/8 ÷ 2/3 = ____________
7. 5/8 ÷ 5/16 = ____________
8. 9 ÷ 3/4 = ____________
9. 2 2/3 ÷ 3 = ____________
10. 3/4 ÷ 3/20 = ____________

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

COMPUTING AREA

In the environmental support career field you will need to find the volume and surface area of tanks. Lets talk about surface area first.

Area is usually measured in square units, such as square feet or square inches. A square foot is a square which measures 1 foot on all sides.

If a tank has a surface area of 500 square feet, that means 500 one foot by one foot squares would cover it exactly. Area is a measure of how many square units it will take to cover an object, or surface area.

To find the area of a square or a rectangle multiply its length by its width. In the case of a square, the length and width are the same number. Because of this, multiplying a number by itself is called squaring the number. Four "squared" is written 4^2 and is equal to 16, or the area of a 4 by 4 square. If the square is 3 feet by 3 feet, the area is 3^2 or 9 square feet. This is usually written 9 ft^2.

How do you find the area of a rectangle that is 2 feet long and 18 inches wide? Is it 36 footinches? The problem is that we don't measure area in footinches. We use square feet (ft^2) or square inches (in^2). So both length and width must be measured in the same units. To do this we can substitute "12 in" for "ft". So 2 ft becomes 2 (12 in) or 24 in and the area is 24 x 18 or 432 in^2. Another way to work the same problem is to substitute "1/12 ft" for "in". So 18 in becomes 18 (1/12 ft) or 3/2 ft (18/1 x 1/12 = 18/12 or 3/2). The problem is now: 2/1 ft x 3/2 ft = 6/2 ft^2 or 3 ft^2.

The formula for the area of a square is A = s x s or s^2. Where A is the area and s is the length of the side as shown in figure 2.

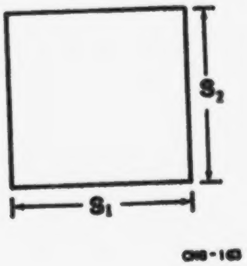


FIGURE 2
Square Area

The formula for the area of a rectangle is: A = l x w. A is the area, l is the length and w is the width as shown in figure 3.

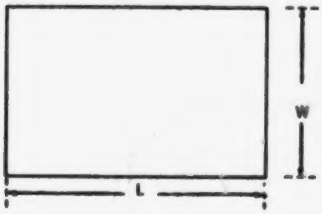


FIGURE 3
Rectangular Area

There are three measurements of a circle we must be familiar with before we can calculate the area of a circle. They are the circumference, the diameter and the radius. The circumference is the distance around the circle (figure 4). The diameter is the distance across the circle going through the center. The radius is the distance from the center to the circle itself. The radius is half of the diameter. If you measure the circumference and the diameter of a circle, you find that the circumference is about 3.14159 times the diameter. This number, 3.14159, is called π , (pronounced pie). We use π because we can always write another digit and get closer to the exact number, but we can never write it exactly as a decimal. We use 3.14 for most of our problems.

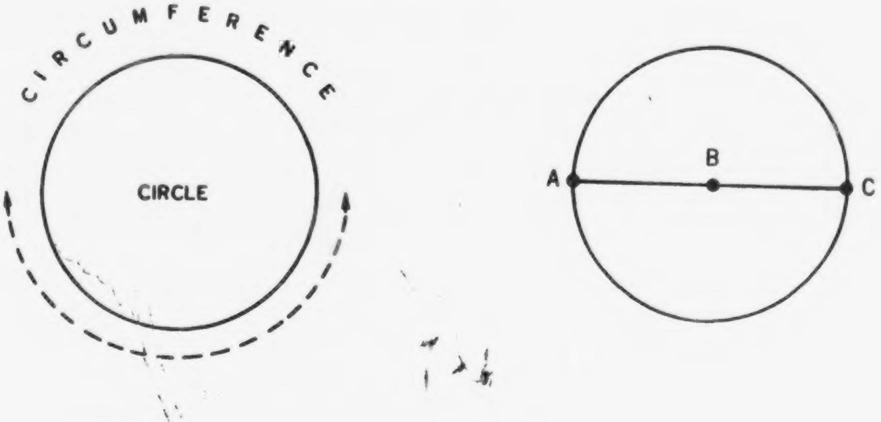


FIGURE 4
Circle

To find the area of a circle use the formula $A = \pi r^2$. A is the area and r is the radius of the circle.

What is the area of a 50 ft circle? First find the radius. If the diameter is 50 ft then the radius must be 25 ft. Now square the radius (25 ft x 25 ft = 625 ft^2). Then multiply by (3.14 x 625 ft^2 = 1961.5 ft^2).

Exercise II-1-d

Instructions: Using appropriate formulas and given the dimensions, correctly determine the area of given geometric figures.

1. Write the formula used to find area of a square.

2. What kind of unit is used to express area?

   a. Find the area of the following squares:

      1. s = 10"
      2. s = 49"
      3. s = 36"
      4. s = 7'
      5. s - 14'
      6. s = 9.8'

b. Find the area of the following rectangles:

1. l = 10", w = 3"
2. l = 43", w = 6"
3. l = 68', w = 45'
4. l = 8", w = 2'
5. l = 12', w = 14'
6. l = 6', w = 36"

c. Find the area of the following circles:

1. r = 27"
2. r = 62"
3. r = 129'
4. r = 14"
5. d = 14"
6. d = 9'

d. Find the area of the following geometric figures:

1. l = 60', w = 49'
2. d = 156'
3. s = 24'
4. s = 159"
5. r = 35"
6. s = 92"
7. l = 4", w = 2"
8. d = 29'
9. s = 47"
10. r = 2.9"

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

COMPUTING VOLUME

To find the volume of a cube, figure 5, or a rectangular container, figure 6, multiply the length by the width to get the area of the bottom. Then multiply by the height, or third dimension. If all the sides are in feet, then the volume has units of cubic feet, written ft^3.

Cube

Formula:
$V = s \times s \times s$ or s^3
V = volume
s = side (cu. units)

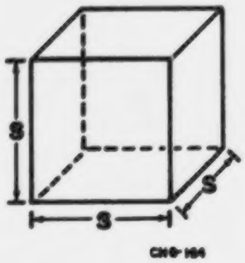


FIGURE 5

Rectangular Container

Formula:

V = l X w X h
V = volume (cu. units)
l = length
w = width
h = height

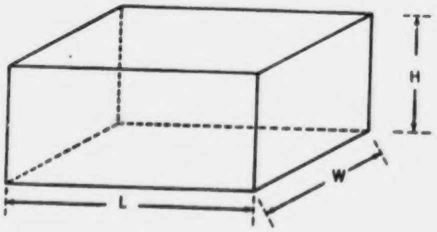


FIGURE 6

To find the volume of a cylinder, figure 7, you first find the area of the bottom, use $A = \pi R^2$ (circle). Then multiply the total area by the height (H) of the cylinder, or the third dimension. If all measurements are in feet, the answer will be cubic feet (ft^3).

Cylinder

Formula:

$V = \pi r^2 h$
V = volume
π = 3.14 (pie)
R = radius
2 = r X r
h = height

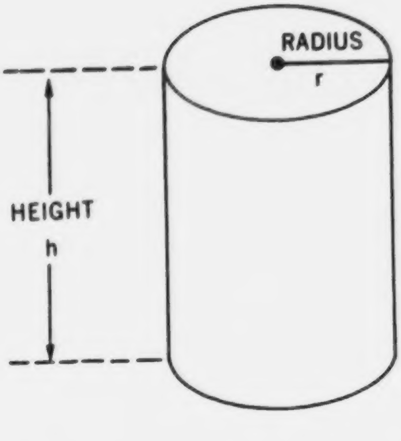


FIGURE 7

Exercise II-1-e

Instructions: Using appropriate formulas and given dimensions, correctly determine the volume of given geometric figures.

1. Write the formula used to find the volume of a cylinder.

2. What kind of unit is used to express volume?

3. Write the formula used to find the volume of a straight sided swimming pool.

4. Find the volume of the following cubes:

   a. s = 10"

   b. s = 49"

   c. s = 36'

   d. s = 124'

   e. s = 6"

   f. s = 9.9'

   g. s = 12.2'

   h. s = 1"

5. Find the volume of the following rectangles

   a. l = 10", w = 3", h = 4"

   b. l = 43', w = 6", h = 26'

   c. l = 68', w = 45', h = 54'

   d. l = 108", w = 64', h = 86'

   e. l = 2", w = 62", h = 2'

   f. l = 3", w = 8", h = 14"

   g. l = 8", w = 4", h = 6'

   h. l = 14", w = 81", h = 27"

6. Find the volume of the following cylinders:

a. d = 144", h = 50'

b. r = 12', h = 100'

c. d = 12", h = 8'

d. r = 30', h = 50'

e. r = 2', h = 24"

f. d = 16", h = 12"

g. r = 8', h = 6'

h. r = 16", h = 2"

7. Find the volume of the following geometric figures:

a. s = 156'

b. d = 118", h = 75"

c. r = 242', h = 10'

d. l = 9", w = 6", h = 8"

e. s = 359'

f. l = 4', w = 2', h = 100'

g. d = 4', h = 22"

h. s = 114'

i. s = 2.22"

j. r = 44', h = 24"

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

WATER SYSTEM PROBLEMS

Now that we have reviewed some basic math, we can apply it to actual operating concepts. In order to do this, it is necessary to know a few formulas that are fundamental to our career field.

Pressure (psi)

A water supply system cannot be operated without putting water under pressure. Pressure is due to force being applied mechanically as with a pump, or due to the weight of the liquid. Pressure is defined as the force acting on a certain area or force per unit area. The pressure in a water works systems is usually stated in pounds per square inch (psi).

Pressure is not affected by the shape of the container or the volume of water, but by the depth of the water measured vertically. Stated as a formula:

$$\text{psi} = \text{feet of water} \times .43$$

For example, what is the water pressure at the bottom of a storage tank holding 170 feet of water? We substitute 170 feet into the above formula to get - psi = 170 feet x .43 = 73.1 psi.

Sometimes we may use the reciprocal of the formula to find the number of feet of water when we know the pressure it exerts. This formula is used when taking pressure gauge readings to determine how much water is in a well or enclosed tank. The formula is:

$$\text{Feet of water} = \text{psi} \times 2.31$$

For example, if the pressure gauge at ground level reads 93 psi, how high is the water level in the storage tank? Substituting 93 psi into the formula, we get Feet = 93 x 2.31 = 214.8 feet.

Pumping Rates

Pumping rates give information about the volume of water that can be pumped over a period of time. Rates are commonly expressed as gallons per minute (gpm), gallons per hour or millions of gallons per day (MGD).

Pumping rates can be used to estimate how much water can be pumped in a specific period of time by using the formula:

$$\text{Pumping rate} \times \text{time} = \text{gallons of water}$$

For example, how many gallons can be pumped in 3 hours by a pump with a pumping rate of 20 gpm? To work this problem the periods of time must be in the same units: therefore, 3 hours must be changed to minutes. After substituting in the above formula, we get 20 gpm x 180 min = 3,600 gallons.

The same concept can be used to find out how long it will take a pump to fill a container of a specific volume. In this case the formula used is:

$$\frac{\text{Gallons}}{\text{Pumping rate}} = \text{time}$$

For example, how long will it take a 15 gpm pump to fill a 10,000 gallon tank? Substituting into the above formula, we get

$$\frac{10{,}000 \text{ gallons}}{15 \text{ gpm}} = 667 \text{ minutes}$$

Since it is not easy to know how long 667 minutes is, we can change the answer to hours by dividing by 60 min/hour.

667 min ÷ 60 min/hr = 11 hours, 7 min

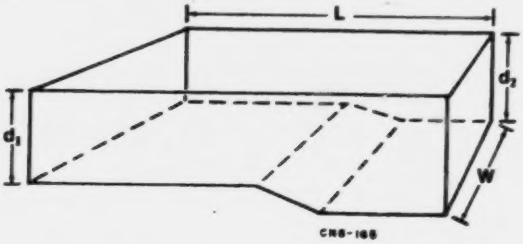
Volume of Water in a Given Container

You may need to know how much water a tank can hold in gallons. First you need to calculate the volume of the container in cubic feet. Knowing this information, it is easy to change cubic feet to gallons using the following formula:

Cubic feet x 7.5 gal/ft^3 = gallons

For example, how many gallons of water are in a tank 20 feet long by 10 feet wide by 10 feet deep? First we have to determine the volume of the tank by multiplying the length by the width and the height. The volume of the tank is 20 ft x 10 ft x 10 ft = 2,000 ft^3. Substituting this in the formula above, we get 2,000 ft^3 x 7.5 gal/ft^3 = 14,960 gallons.

In the case of a swimming pool with an uneven bottom such as pictured below, a slight change must be made in the calculation of the volume of the pool. In this case an average depth may be found by adding the depth at the shallow end to the depth at the deep end and dividing by 2.



Suppose this pool is 60 feet long by 25 feet wide. It is four feet deep in the shallow end and 12 feet deep at the deep end. How many gallons of water does it contain? First, find an average depth by adding the two depths and dividing the sum by 2. $\frac{4 + 12}{2}$ = 8 ft average depth. The volume of the pool can now be calculated by multiplying the length by width by average depth. 60 ft x 25 ft x 8 ft = 12,000 ft^3. Now multiply 12,000 ft^3 by 7.5 to change it to gallons. 12,000 ft^3 x 7.5 gal/ft^3 = 90,000 gallons in this swimming pool.

Weight of a Specific Volume of Water

A gallon of water weighs 8.34 pounds. Knowing this will let you estimate how much a specific volume of water weighs. Therefore, using the formula:

gallons x 8.34 lbs/gal = weight

we can calculate the weight of 1 million gallons of water. Substituting 1,000,000 gallons into the above formula, we find 1,000,000 x 8.34 = 8,340,000 pounds.

Chemical Computations

Two terms are commonly used to express the concentration of chemicals in water or wastewater. One term is "parts per million" (ppm). A concentration of 1 ppm chlorine means there is one pound of chlorine in one million pounds of water. The other term commonly used is milligrams per liter (mg/L). A concentration of one mg/L of chlorine means that there is one milligram of chlorine in one liter of water. The use of mg/L and ppm for practically the same thing is confusing. Generally the mg/L term is used for chemical analysis results to show the concentration of substances in the water, and ppm is used for chemical addition to water at the plant. In our operation 1 ppm is the same as 1 mg/L.

This information is used in calculating the amount of chemicals required to treat a specific amount of water to a particular dosage. The formula used is:

lbs of chemical = ppm x 8.34 x MG

In this formula, the ppm is the dosage or concentration of the chemical that is to be added to the water. MG is the amount of water expressed in terms of millions of gallons.

For example, how many pounds of chemical are required to treat 500,000 gallons of water to a concentration of 3.0 ppm? Substituting into the above formula we get lbs of chemical = 3.0 ppm x 8.34 x .5 MG. (Since we do not have a million gallons of water, we can find out what part of a million gallons we have by dividing our number of gallons by 1,000,000.) Working this out we find that we need 12.51 lbs of chemical to treat our water.

In many cases the chemicals we buy from the suppliers are not 100% pure. If this is so, we would have to increase the amount of chemical added to give us the same amount of usable chemical. The above formula can be changed to take this into account. In the case of using chemicals less than 100% pure, the formula becomes:

$$\text{lbs of impure chemical} = \frac{\text{ppm x 8.34 x MG}}{\text{\% purity (decimal value)}}$$

Exercise II-1f

Solve these mathematical problems pertaining to a typical water supply system.

1. A swimming pool measures 75 ft by 50 ft and is 4 ft deep at one end and 12 ft deep at the other end.

    a. How large (what volume) is the pool?

    b. How many gallons of water will this pool hold?

    c. If a pump delivers 60 gpm to this pool, how long will it take to fill it up in minutes? In hour and minutes?

2. How long would it take a 120 gpm pump to fill a pool 50 ft long, 20 ft wide and an average depth of 7 ft?

3. A water storage tank 60 ft high with a 30 ft diameter will hold how many gallons of water?

4. Assuming the tank in #3 is full, what would be the psi at the bottom of the tank?

5. You are told to disinfect a tank of water which holds 500,000 gallons of water. In stock there is some dry powder chlorine that is 65% pure. How many pounds of this chlorine will it take to treat the water to a 5.0 mg/L concentration?

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

Temperature Conversion

Temperature is usually measured on either of two scales, Fahrenheit (°F) or Celcius (°C). You are probably more familiar with the Fahrenheit scale on which water freezes at 32°F and boils at 212°F. Most of the world uses the Celsius scale on which water freezes at 0°C and boils at 100°C. From freezing to boiling is 180 Fahrenheit degrees and 100 Celsius degrees. So in terms of change of temperature, 180°F = 100°C

Which means 180°F/100°C = 1

Reducing we get $9°F/5°C = 1$, so $5°C/9°F = 1$ too.

Because these ratios are equal to one they can be used to change from one scale to the other. If the temperature has risen by 10°C then $9°F/5°C \times 10°C = 18°F$, the temperature has risen by 18°F. To change from one scale to the other we must also adjust for the fact that freezing is zero on one scale and thirty-two on the other.

To change 20°C to Fahrenheit think of it as 20 Celsius degrees above freezing. Multiply by $9°F/5°C$ to get 36 Fahrenheit degrees above freezing or 68°F. So the formula is $\underline{F = 9/5C + 32}$. Where F is the Fahrenheit temperature and C is the Celcius temperature.

To change from Fahrenheit to Celsius first find out how far from freezing the temperature is. For example 98.6°F is 66.6 Fahrenheit degrees above freezing which is: $5°C/9°F\ (66.6°F) = 37°C$ since zero is freezing no further adjustment is needed. So the formula is: $\underline{C = 5/9\ (F-32)}$ where C is the Celsius temperature F is the Fahrenheit temperature and the parenthesis means to subtract 32 before multiplying.

Exercise II-1-2

1. Write both formulas for converting the temperature scale.

2. Change the following C° temperatures to F° and F° to C°.

   a. C° = 10°
   b. C° = 26°
   c. C° = 18°
   d. C° = 100°
   e. F° = 68°
   f. F° = 20°
   g. F° = 100°
   h. F° = 212°

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

In this study guide, we have discussed some of the common mathematical problems and formulas used in water treatment. We discussed the basic procedures on how to solve decimal and fractional problems. We learned how to find area and volume of a container, how to convert volume to gallons, and how to use pumping rate to find the time it takes to fill a container. We learned how to use psi to find depth of water in a tank and how to convert temperature scales.

PRINCIPLES OF PHYSICS

OBJECTIVE

Using information and a list of eight incomplete statements concerning physics, complete the statements. Five of the eight statements must be correct.

INTRODUCTION

The fundamental concepts of physics are essential for you to thoroughly understand and perform in the environmental support field. Following are the fundamentals of physics which will contribute greatly to your understanding of the water and wastewater treatment processes.

- Principles of Physics
- Energy
- Matter
- Structure of Matter

INFORMATION

PRINCIPLES OF PHYSICS

Physics is a science that deals with matter and energy. Physics deals with physical changes in matter and changes caused by the application of energy. A physical change is a change in the form or state of a substance in which no new substance is formed. An example of a physical change is the freezing of water to form ice.

Energy

Energy is defined as the capacity to do work. It may appear in many forms. Some forms of energy you may be familiar with are heat, light, sound, mechanical energy, electrical energy, and chemical energy. Energy can be changed from one form to another. For example the energy stored in fuel can be released during burning to produce heat, a different form of energy. The energy produced by falling water can be used to drive a generator and produce electricity, another form of energy.

Two general classifications of energy often studied are potential energy and kinetic energy. Potential energy is due to the position or composition of something; kinetic energy is due to its motion or change. A compressed spring has potential energy due to its position which is changed to kinetic energy when it is released.

Matter

Matter is defined as anything that occupies space and has mass or weight. Experience has shown that under ordinary circumstances, matter cannot be created nor destroyed. It can however, be changed from one form to another.

Matter may exist in three different physical states or forms: solid, liquid, or gas. Solids are rigid and have a definite volume and shape. Liquids flow and assume the shape of the container they are in, but they do keep a definite volume. Gases on the other hand have neither a definite volume nor shape. Gases will diffuse and "fill" any container in which they are placed.

It is possible to change matter from one form to another by changing the condition under which it is stored. One way to change matter from one form to another is to change the temperature. Water is easily changed from its solid form (ice) to its liquid form to its gaseous form (vapor) by changing the temperature of its surroundings. This is true of all matter. Another way to change the form of matter is to change the pressure it is under. If we increase the pressure on chlorine gas in a container, it will liquify. If we increased the pressure even more, it would begin to change into the solid form.

Structure of Matter

ATOMS: All matter is made up of basic units called atoms. An atom is the smallest part of an element that can show the properties of the element. An atom of any element, if we could obtain just one atom, would look, feel, smell and act like a larger number of atoms of the element. Atoms are complex systems composed of smaller particles. Three of these are of interest to us: protons, neutrons and electrons.

PROTONS. Protons are positively charged particles in the nucleus of an atom. The number of protons in the nucleus determines which element we have.

NEUTRONS. Neutrons are neutral or uncharged particles in the nucleus of an atom. They may vary in number in atoms of the same element.

ELECTRONS. Electrons are negatively charged particles in orbit around the nucleus. These electrons move according to definite patterns sometimes called shells. Since all elements are observed to be electrically neutral, then there must be the same number of electrons as there are protons.

MOLECULES. Two or more atoms which are chemically combined form a molecule. The atoms may be of the same element or different elements. The elements hydrogen, oxygen, nitrogen, fluorine, chlorine, bromine and iodine consist of diatomic molecules (two atoms per molecule). If the atoms are of different elements, they form what is called a compound which we will discuss in greater detail in the following unit. Regardless of whether the molecule is of an element or a compound, the molecule is the smallest part of a substance which has all the properties and characteristics of that substance.

SUBSTANCES. Substances have two major classes of properties: physical and chemical. Physical properties describe a substance as it is. We use physical properties to tell one substance from another, for example: density, color, odor, boiling point and solubility. Chemical properties are those which tell how the substance reacts in the presence of other substances, for example: reaction with water, rusting in air, decomposition by electricity. These are actually chemical changes which produce new products.

SUMMARY

Physics is an essential part of understanding the processes of water and wastewater treatment. The principles of physics covered in this chapter will aid you greatly in your success in the environmental support field.

Exercise II-2-a

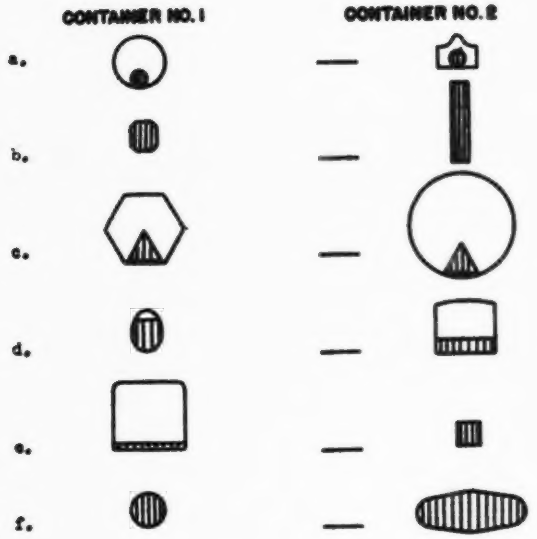
Instructions: Complete the following statements.

PART I

1. Physics is the science dealing with ____________________.
2. Energy is defined as ____________________.
3. Some forms of energy are ____________________.
4. The three forms of matter are ____________________.
5. The smallest part of an element is called ____________________.
6. The sub-atomic particle with a negative charge is ____________________.
7. The sub-atomic particle which determines the identity of the element is ____________________.
8. Two or more atoms which are chemically combined form ____________________.
9. Why is a shadow not considered matter? ____________________.
10. Color is considered a ____________________ property.

PART II

Instructions: After accomplishing the basic physics and matter training manual, 2PTP-5120-03, complete the following exercise. Identify the states of matter by writing "G" for gas, "S" for solid, and "L" for liquid in the spaces provided between each set of diagrams, showing the transfer of states of matter from one container to the other. The lined area represents the space occupied by matter.



PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

3770 Technical Training Group
Sheppard AFB, Texas

SG J3ABR56631 000-II-3

PRINCIPLES OF CHEMISTRY

OBJECTIVE

Given a list of twenty chemical terms, elements, radicals and other related terms, match them with their definitions and/or symbols. Sixteen of the twenty terms must be correct.

Given a list of fifteen chemical compounds and their formulas, match the chemical compounds with their formulas and indicate whether the compound is an acid, base, or salt. At least twelve of the fifteen must be correct.

Given a list of ten compounds, write formulas describing each compound. Seven of the ten formulas must be correct.

Given five sets of reactants, write balanced chemical equations. Three of the five must be correct.

INTRODUCTION

To fully and effectively treat and test water and wastewater involves the use of chemicals, reagents, and laboratory equipment. You do not have to be a chemist to be able to test or treat water and wastewater, but an understanding of basic chemistry is useful. The study of chemistry raises many different and challenging ideas.

INFORMATION

Chemistry is the branch of science which deals with the composition of all forms of matter and with the changes which that matter can undergo. We will limit our study of chemistry in this course to those areas which pertain to water and wastewater treatment. Information in this unit will be presented on the following subjects:

* Chemical terminology
* Solutions
* Acids, bases and salts
* Balancing formulas
* Balancing equations

TERMS

Chemical Terminology

Certain commonly used terms are part of the language of chemistry. A basic vocabulary must be built in order to understand some of the fundamental ideas in the field of chemistry.

CHEMISTRY. Chemistry can be defined as the study of the composition, structure, and properties of matter, and the changes which it undergoes. Matter is anything that has weight or mass, and occupies space. Matter is made up of either pure substances or mixtures of pure substances. Most of our discussion will be directed toward the study of the pure substances.

MATTER. Matter can be generally divided into two large groups, organic matter or inorganic matter. Organic matter was once defined as anything that is living or has lived at one time. A more up to date definition would be any substance which has the element carbon as part of its composition. The elements hydrogen and oxygen are combined with carbon in most organic substances. Examples of organic matter are oil, coal, sugars, methane gas, and proteins.

Inorganic matter is the opposite of organic matter in that it has never lived and does not contain the element carbon. Like most rules, this rule has exceptions. Carbon monoxide (CO), carbon dioxide (CO_2), carbonate (CO_3) compounds, and bicarbonate (HCO_3) compounds contain carbon and yet are considered inorganic.

ELEMENTS. We briefly touched on the subject of elements in the previous unit of this study guide. Now we will go into more detail. An element is the simplest form of matter. It cannot be formed from simpler substances nor can it be decomposed into simpler substances. Some elements exist free in nature. Others are found only combined with other elements. Either way, elements are the things which make up every kind of matter in the world.

Periodic Table of the Elements. The Periodic Table is a systematic arrangement of the elements used by scientists around the world. It gives useful facts at a glance about every element known to man. Information about each element can be found in the box which has both its name and symbol. A symbol is a letter or combination of two letters which represents the name of the element. It is a type of chemical shorthand or abbreviation. The elements are listed in order of increasing atomic number. The atomic number tells how many protons are in the nucleus of an atom of that element. The atomic weight is a way of comparing the weight of one atom of an element with one atom of another element. You can tell whether an element is usually liquid, gas or solid by looking at the color of the symbol. You can also predict whether it is a metal, metalloid, or non-metal by looking at its position on the table.

COMPOUNDS. Most matter occurs as compounds or mixtures of compounds. A compound is a substance composed of two or more elements which are chemically combined. When a chemical combination takes place, the elements that are combining lose their properties and the compound formed will have a whole new set of properties that identify it. For example the element sodium is a soft silvery-white metal that can be ignited by the moisture on your skin. The element chlorine is a greenish-yellow gas that is deadly to breathe. These two elements combine to form a new substance, a compound known as "table salt", that has no resemblence to the elements that make it.

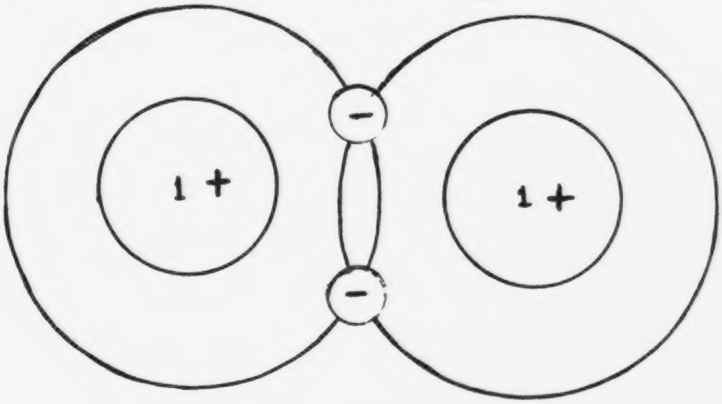
The chemical shorthand for the name of a compound is known as a formula. It is made up of the symbols of all the elements that are a part of the compound. Small numbers called subscripts show how many atoms of each element are combined in one molecule of that compound. A molecule is the smallest part of a compound which can still exhibit all the properties of the compound.

Compounds are named according to several methods. Binary compounds consist of two elements. The name of the compound consists of the names of the two elements, with the second name having its ending changed to -ide, such as $NaCl$ = sodium chloride; $AgCl$ = silver chloride. An old method of naming compounds made from certain metals is to add -ic or -ous to the Latin names of the metals. $FeCl_2$ = ferrous chloride; $FeCl_3$ = ferric chloride. There are also many common names that are in use for chemicals that are used in water systems. Lime is $Ca(OH)_2$ = calcium hydroxide. Caustic is $NaOH$ = sodium hydroxide. The common names are frequently used in the field in place of the chemical names. Therefore it will help you to know them also.

BONDING. Bonds are the forces which hold the atoms together to form molecules. Without bonding we would not have any compounds. There are two types of bonds: electrovalent (ionic) and covalent.

As we have mentioned before, electrons are in orbit in "shells" around the nucleus of the atom. Each shell has a maximum number of electrons it can hold. When the outermost shell is filled with electrons (never more than eight), the atom is in its most stable form. Atoms which do not have filled shells will gain, lose or share electrons with other atoms in order to get a filled outer shell. The electrons which are involved in this gain, loss or sharing are called valence electrons. The valence or oxidation state is defined as the relative combining capacity of an element and shows how many electrons are involved in the bonding.

Covalent Bonding. If the electrons are shared between atoms, a covalent bond is formed. The simplest example of covalent bonding is found in the molecule of hydrogen gas. The hydrogen atom has one electron only. Since this is unstable, if no other element is available for hydrogen atoms to react with, two hydrogen atoms will combine with each other to form a hydrogen molecule. The two hydrogen atoms share their electrons between them forming a covalent bond.



Electrovalent Bonding. Electrovalent bonding is a chemical combination of two or more elements in which a transfer of one or more electrons occurs. This type of bonding is also called ionic bonding. Consider for a minute the structure of an atom of sodium. It has eight electrons in its next outermost shell and one electron in its outermost shell. If the lone electron could be removed from the sodium atom, the remaining electron shells would be filled, leaving sodium in a more stable form. Removing an electron would cause the sodium atom to have one extra positive charge. We call a charged particle of this type an ion.

Next consider an atom of the element chlorine. It has seven electrons in its outermost shell. The gain of one more electron would give it a filled shell and a much more stable form. The chlorine atom will accept the electron from the sodium atom and in doing so will gain an extra negative charge. Once the electron has been transferred from the sodium atom to the chlorine atom, we then have oppositely charged ions which can attract one another electrically. They do so to form an ionic or electrovalent bond, making the compound sodium chloride, ordinary table salt.

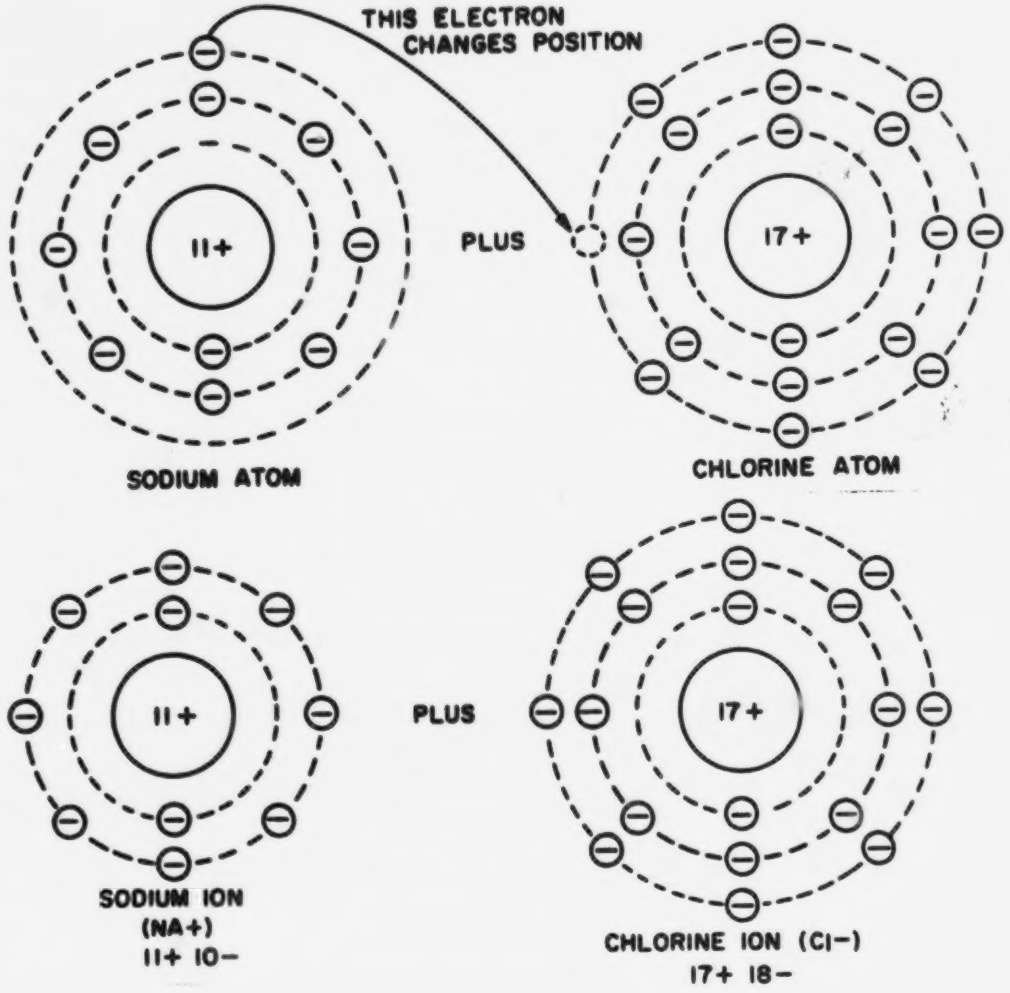

THIS ELECTRON CHANGES POSITION
11+
PLUS
17+
SODIUM ATOM
CHLORINE ATOM
11+
PLUS
17+
SODIUM ION (NA+) 11+ 10-
CHLORINE ION (Cl-) 17+ 18-

FIGURE 3-2. Bonding Process

NAME	SYMBOL & CHARGE	NAME	SYMBOL & CHARGE
Acetate	$(C_2H_3O_2)^-$	Hydroxide	$(OH)^-$
Ammonium	$(NH_4)^+$	Hypochlorite	$(OCl)^-$
Antimony	Sb^{+++}	Iodate	$(IO_3)^-$
Barium	Ba^{++}	Iodide	I^-
Bicarbonate	$(HCO_3)^-$	Iron (Ferrous)	Fe^{++}
Bismuth	Bi^{+++}	Iron (Ferric)	Fe^{+++}
Bromide	Br^-	Lead (Plumbous)	Pb^{++}
Aluminum	Al^{+++}	Magnesium	Mg^{++}
Cadmium	Cd^{++}	Manganous	Mn^{++}
Calcium	Ca^{++}	Mercurous	Hg^+
Carbon	C^{++++} or C^{----}	Mercuric	Hg^{++}
Carbonate	$(CO_3)^=$	Nickel	Ni^{++}
Chlorate	$(ClO_3)^-$	Nitrate	$(NO_3)^-$
Chloride	Cl^-	Nitrite	$(NO_2)^-$
Chlorite	$(ClO_2)^-$	Oxalate	$(C_2O_4)_=$
Chromate	$(CrO_4)^=$	Oxide	$O^=$
Chromium	Cr^{+++}	Perchlorate	$(ClO_4)_-$
Cobalt	Co^{++}	Permanganate	$(MnO_4)_-$
Copper (Cuperic)	Cu^{++}	Phosphate (ortho)	$(PO_4)^{=-}$
Cupric Ammonia	$Cu(NH_3)_4^{++}$	Potassium	K^+
Copper (Cuperous)	Cu^+	Silicate (ortho)	$(SiO_4)^{==}$
Cyanide	$(CN)^-$	Silver	Ag^+
Dichromate	$(Cr_2O_7)^=$	Sodium	Na^+
Ferricyanide	$Fe(CN)_6^=$	Sulfate	$(SO_4)^=$
Fluoride	F^-	Sulfite	$(SO_3)^=$
Formate	$(HCO_2)^-$	Thiosulfate	$(S_2O_3)^=$
Hydrogen	H^+	Tin (Stannous)	Sn^{++}
Strontium	Sr^{++}	Zinc	Zn^{++}
Sulfide	$S^=$		

FIGURE 3-3. Chemical Data and Valence of Common Ions

Exercise II-3a

PART I

Instructions: Using a periodic chart of the elements, and given the element name, fill in the chart below by finding the symbol, atomic number, atomic weight and most stable valence of each element given.

ELEMENT	SYMBOL	ATOMIC NUMBER	ATOMIC WEIGHT	VALENCE
1. Carbon				
2. Calcium				
3. Magnesium				
4. Sodium				
5. Iron				
6. Oxygen				
7. Hydrogen				
8. Nitrogen				
9. Aluminum				
10. Copper				
11. Chlorine				
12. Manganese				
13. Potassium				
14. Silver				
15. Gold				

PART II

Instructions: Enter the chemical symbol beside each of the following elements and indicate valence.

1. Hydrogen ______
2. Oxygen ______
3. Sodium ______
4. Magnesium ______
5. Calcium ______
6. Chlorine ______
7. Carbon ______
8. Iron ______
9. Potassium ______
10. Barium ______
11. Aluminum ______
12. Fluorine ______

PART III

Instructions: Name the following binary compounds.

1. NaCl ______________________________
2. CaO ______________________________
3. ZnS ______________________________
4. AgI ______________________________
5. KBr ______________________________
6. BaO ______________________________

NON-ELECTROLYTES. Solutions which are not able of conducting an electrical current are called non-electrolytes. These solutions are generally made by dissolving compounds formed with covalent bonds is water. Solutions made with sugar or alcohol in water are good examples of non-electrolytes.

ELECTROLYTES. Solutions which are able to conduct an electric current are called electrolytes. The current is carried when charged particles called ions move through the solution. The ions are formed when compounds held together by ionic bonds are dissolved in the water or when a reaction occurs between molecules of water and other covalently bonded compounds creating ions. This process is called ionization.

If the ions are positively charged from the loss of electrons, they are called cations. Negatively charged ions formed by the gain of electrons are called anions. There is also a group of polyatomic ions (formed from more than one atom) which are sometimes called radicals. These radicals keep their identity as a charged particle and do not separate under normal chemical conditions. A radical may be either a cation or an anion. Nine common radicals which we deal with are as follows:

1. $CO_3^{=}$ carbonate
2. HCO_3^- bicarbonate
3. OH^- hydroxide
4. $SO_4^{=}$ sulfate
5. MnO_4^- permanganate
6. PO_4^{-3} phosphate
7. NO_3^- nitrate
8. OCl^- hypochlorite
9. NH_4^+ ammonium

Positive and negative ions have the ability to carry an electrical current through water. To prove this we can fill a glass with water, dump in a teaspoon of salt, and rig up an electrical extension and light bulb as shown in the figure below. When ionization occurs the current is carried through the water and the light bulb will glow.

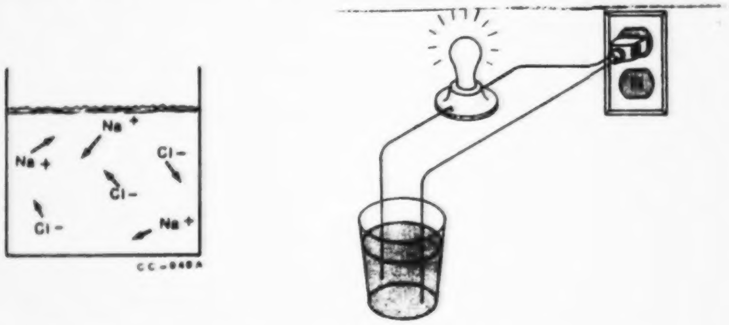


FIGURE 3-4. Sodium Chloride and Water

PART IV

Instructions: Write the chemical formula for each of the following ions. Show the positive or negative charges.

1. Ammonium ______
2. Hydroxide ______
3. Carbonate ______
4. Bicarbonate ______
5. Sulfate ______
6. Permanganate ______
7. Nitrate ______
8. Phosphate ______
9. Hypochlorite ______

PART V

Instructions: Write the name of the following ions:

1. Ca^{++} ____________
2. Cl^- ____________
3. $CO_3^{=}$ ____________
4. Mg^{++} ____________
5. $SO_4^{=}$ ____________
6. Fe^{++} ____________
7. Al^{+++} ____________
8. $PO_4^{=-}$ ____________
9. H^+ ____________
10. OH^- ____________
11. Na^+ ____________
12. K^+ ____________

Solutions

What is a solution? A solution is a uniform mixture of two or more substances. The possible combinations of components which will form solutions include gas into gas, gas into liquid, liquid into liquid, and solid into liquid. We will confine our solutions to water or liquid solutions in this field, however. This will give us three forms of solutions: gas in liquid, liquid in liquid, and solid in liquid. In each case the liquid is the dissolving medium called the solvent. The substance being dissolved is the solute. Since almost all the chemistry of water treatment takes place in solutions, it is important to be familiar with the ways of expressing concentrations of solutions.

Types of Solutions

CONCENTRATED. A concentrated solution is one in which a large amount of solute is dissolved in the solvent.

DILUTE. A dilute solution is one in which a small amount of solute is dissolved in the solvent.

SATURATED. A saturated solution is one in which the solvent holds all the solute that it can at that particular temperature.

SUPERSATURATED. A supersaturated solution holds more solute than would be expected at that temperature. Sometimes a saturated solution prepared at a higher temperature can be carefully cooled so that the solute does not get a chance to come out of solution. At the cooler temperature the solution holds more solute in solution than it would for saturation and is said to be supersaturated.

NORMAL. A normal solution is one that is prepared specifically for laboratory use. A one normal solution is indicated by the symbol 1 N on the label of the container and means that it contains one gram-equivalent of solute in one liter of solution. Obviously a solution that is .1 N is not nearly as concentrated as one that is 1 N.

WATER - THE UNIVERSAL SOLVENT

By any standard, water is the most important chemical compound on earth. It is also the most abundant compound. It is important to all life processes. It is a necessary part of most chemical reactions, either as a reactant or as the medium in which the reactions take place.

Molecular Structure. Much of the behavior of water can be explained by studying the water molecule itself. The water molecule is made up of two hydrogen atoms bonded covalently to one oxygen atom. The hydrogen atoms do not bond on either side of the oxygen like this: H - O - H. Instead they are both off to one side of the oxygen similar to this:

This structure gives the water molecule what is called a polar characteristic or a positive end and a negative end. There is also an attraction for the positive end of the water molecule for the negative end of nearby water molecules creating what is called hydrogen bonding. The hydrogen bonding and the polarity of the water molecule are two of the factors which make water such a good solvent or able to dissolve so many different things.

Ionization of Water. As we have seen ions can create a way for electricity to be carried through water. Water has the ability to ionize slightly, creating hydrogen ions and hydroxide ions. Pure water is a very poor electrolyte because there is such a small concentration of ions.

Reaction with Metal Oxides. Many metals are combined with oxygen to form a group of compounds called metal oxides. These metal oxides will react with water to form a group of chemicals we call bases. Many of these reactions release a lot of heat as well.

Reaction with Non-Metal Oxides. A few compounds are formed by non-metals with oxygen. These compounds are called non-metal oxides. Some of these non-metal oxides will react with water to form a group of compounds called acids.

PART VI

Instructions: The purpose of this exercise is to aid you in learning the definitions of chemical terms. Place the letter identifying the correct term in the blank space preceding the definitions in Column I.

COLUMN I

1. ( ) Anything that has weight, or mass and occupies space.
2. ( ) Radicals
3. ( ) Science pertaining to reactions of elements and compounds
4. ( ) Two or more elements chemically combined
5. ( ) Compounds composed of carbon
6. ( ) Symbols
7. ( ) A type of bonding
8. ( ) Smallest particle of element
9. ( ) A solution containing all the solute it will dissolve at that particular temperature
10. ( ) A solution which can conduct an electric current
11. ( ) A substance composed of only one kind of atom
12. ( ) A solution containing a large amount of solute per unit volume
13. ( ) A substance which has been dissolved
14. ( ) A substance which will dissolve another substance
15. ( ) A uniform mixture of two or more substances in liquid form

COLUMN II

a. solute
b. $(CO_3)^=$, $(SO_4)^=$, $(NH_4)^+$
c. solvent
d. chemistry
e. Ca, Mg, Na, H, O_2
f. matter
g. compounds
h. organic matter
i. energy
j. electrovalent
k. concentrated solution
l. saturated solution
m. element
n. atom
o. electrolyte
p. valence
q. solution

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

ACIDS, BASES, AND SALTS

Whether you are aware of it or not, you have dealt with acids, bases, and salts all your life. There are three groups of chemicals which include many of the substances you eat and use for cleaning.

Acids. An acid is a substance, usually a liquid, that contains hydrogen and is ionized in water. Acid solutions have the following common characteristics: They have a sour taste; they react with many metals to give off hydrogen gas; they neutralize bases; they are electrolytes.

Since they are electrolytes, we can classify acids as stong or weak according to how much they ionize in water. Strong acids will ionize easily and should be handled with care. When an acid is poured into water, the hydrogen in the acid breaks away and is in the water as an ion. It is very active and will react with almost anything it contacts. Weak acids on the other hand do not ionize to a great degree, so the number of hydrogen ions available to react is smaller. Therefore the reaction will be slower and less violent.

Acids like other solutions, may be classified as concentrated or dilute according to how much water is present as the solvent. A concentrated acid is an acid which contains very little water. An example of this is concentrated sulfuric acid which is 98% acid and only 2% water. Sulfuric acid happens to be a strong acid as well, but we can make it a dilute acid by adding it to a large amount of water. It will still be a strong acid, but now it is a dilute strong acid.

Most of the acids we use in this field have common names that they are referred to by. Sometimes we call them by their chemical formulas as well. The most common ones are listed below. Notice that the formula for each acid begins with a hydrogen ion.

H_2SO_4	Sulfuric acid
HCl	Hydrochloric acid
H_2CO_3	Carbonic acid

Bases. A Base is a substance that contains the hydroxide ion and is ionized in water. Bases are considered to be the opposite of acids. Bases share some similar characteristics: They have a bitter taste; they have a slick feeling; they neutralize acids; they are electrolytes.

Bases can also be classified as strong or weak according to how much they ionize in water and form hydroxide ions. They can be concentrated or dilute according to how much water they are mixed in.

Two of the bases we commonly use in this field are listed below. They also are known many times by their common names rather than the proper chemical name. Notice that the formula for the bases ends in OH.

$NaOH$	Caustic or caustic soda
$Ca(OH)_2$	Lime or slaked lime

Salts. Salts are ionic compounds that do not release either hydrogen or hydroxide ions when dissolved in water. Many times they are made by neutralizing an acid with a base. This reaction will form a salt and water. Salts vary greatly in their properties except their ionic bonds. They may taste salty, sour, bitter, sweet, or have no taste at all. They are all electrolytes. Some examples of salts are sodium chloride, calcium chloride and barium sulfate.

Exercise II-3-b

Instructions: Inorganic compounds are classed as either acids, bases, or salts. List the following compounds in the correct column in the table.

1. $Na(OH)$
2. $Ca(OH)_2$
3. $CaCl_2$
4. $H_2(SO_4)$
5. $Ca(HCO_3)_2$
6. $H_3(PO_4)$
7. $NaCl$
8. $MgCl_2$
9. $Ca(CO_3)$
10. HF
11. $Mg(OH)_2$
12. $K(OH)$
13. $Al(OH)_3$
14. $Ca(SO_4)$
15. HCl
16. $Mg(CO_3)$
17. $H(NO_3)$
18. $H_2(CO_3)$
19. $FeCl_2$
20. $Fe_2(SO_4)_3$

ACIDS	BASES	SALTS

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

WRITING BALANCED FORMULAS

When writing chemical formulas there are certain steps that must be followed in order to come up with the correct formula. The chemical name is a good starting point for writing the formula. Common names are usually not helpful.

STEPS REQUIRED IN WRITING BALANCED FORMULAS FOR COMPOUNDS

	Sodium Chloride	Calcium Hydroxide
1. Write the symbol for the cation.	Sodium - Na	Calcium - Ca
2. Indicate the valence of the cation.	Na^+	CA^{++}
3. Write the symbol for the anion.	Chloride - Cl	Hydroxide - OH
4. Indicate the valence of the anion.	Cl^-	OH^-
5. Balance the electrical charges of the cation and anion with the use of subscript.	$Na^+ Cl^-$	$Ca^{++} OH^-{}_2$
6. Enclose polyatomic ions in parenthesis when more than one is required.		$Ca^{++}(OH^-)_2$

A subscript is a small number (written below the line) following a symbol or ion in a formula. It shows the number of that particular atom or ion contained in that formula. In the formula Fe_2O_3 there are two atoms of iron combined with three atoms of oxygen.

Exercise II-3c

PART I

Instructions: Write the formulas in the blank spaces provided showing the compounds which would be formed when each of the cations combine chemically with each of the anions.

/////	$O^{=}$	Cl^{-}	$(OH)^{-}$	$(CO_3)^{=}$	$(SO_4)^{=}$	$(HCO_3)^{-}$	$(PO_4)^{=-}$
H+							
Na+							
Ca++							
Mg++							
Fe+++							
Fe++							
Al+++							
Pb++							
Zn++							
Cu++							

PART II

Instructions: Write the formulas for the following compounds, include symbols, subscripts and valences.

1. Sodium carbonate __________
2. Sodium chloride __________
3. Calcium bicarbonate __________
4. Calcium carbonate __________
5. Calcium chloride __________
6. Magnesium carbonate __________
7. Magnesium oxide __________
8. Hydrogen sulfate __________
9. Hydrogen carbonate __________
10. Potassium hydroxide __________
11. Potassium chloride __________
12. Aluminum hydroxide __________
13. Aluminum sulfate __________
14. Calcium oxide __________
16. Ferric oxide __________
17. Silicon dioxide __________
18. Zinc carbonate __________
19. Magnesium bromide __________
20. Barium carbonate __________
21. Sulfuric acid __________
22. Hydrochloric acid __________
23. Carbonic acid __________
24. Hydrogen fluoride __________
25. Silicon fluoride __________
26. Ammonium hydroxide __________
27. Silver nitrate __________
28. Zinc carbonate __________
29. Ferric hydroxide __________

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

WRITING BALANCED CHEMICAL EQUATIONS

A chemical equation is a statement which shows a chemical change. It is written using chemical symbols which can be easily interpreted. The format for writing a chemical equation is as follows:

$$\text{reagents(s)} \longrightarrow \text{product(s)}$$

A reagent is a substance which is going to change and a product is a substance which is formed during the reaction. The arrow is read "yields" or "produces".

Common Types of Chemical Reaction. In looking at written equations, there seems to be four basic types. These are combination, decomposition, single displacement, and double displacement.

COMBINATION. Combination can also be called synthesis. This means a new compound is formed by the addition of elements. An example of this type is

$$2\ H_2 + O_2 \longrightarrow 2\ H_2O$$

In this type of reaction two or more different reactants add together to form a single product.

DECOMPOSITION. In a decomposition reaction a breakdown of a compound occurs. An example of this type of reaction is

$$2\ HgO \longrightarrow 2\ Hg + O_2$$

In this type of reaction a single reactant is decomposed to form two or more different products.

DISPLACEMENT. Sometimes called single displacement, it is a reaction where one substance is displacing another. An example of this is

$$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$$

In this type of reaction an element and a compound react to form another element and compound.

DOUBLE DISPLACEMENT. In this type of reaction there is an actual exchange of partners to form new compounds. An example of this type of reaction is of partners to form new compounds. An example of this type of reaction is

$$AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$$

In this reaction two compounds reacted to form two new compounds. This is an especially important type of equation because so many reactions are of the double displacement type.

OXIDATION-REDUCTION. Another, more complicated type of reaction is called oxidation-reduction. In these reactions a change in valence or oxidation state occurs. One substance will undergo oxidation which is a loss of electrons. Another substance will at the same time undergo a reduction which is a gain in electrons. One example of this type of equation is

$$4\ Fe(OH)_2 + O_2 + 2\ H_2O \longrightarrow 4\ Fe(OH)_3$$

In this equation the valence of iron increases from +2 to +3 and the valence of oxygen decreases from 0 to -2. The iron is oxidized and oxygen is reduced.

Exercise II-3d

Part 1

Instructions: Write the type of reaction shown by the following equations.

1. $2\ KClO_3 \longrightarrow 2\ KCl + 3O_2$ ______________________________

2. $H_2 + Cl_2 \longrightarrow 2\ HCl$ ______________________________

3. $Zn + Cu(NO_3)_2 \longrightarrow Cu + Zn\ (NO_3)_2$ ______________________________

4. $AgNO_3 + KCl \longrightarrow AgCl + KNO_3$ ______________________________

5. $FeCl_3$ _ $KOH \longrightarrow Fe(OH)_3 + KCl$ ______________________________

6. $Fe_2O_3 + 3\ C \longrightarrow 2\ Fe + 3\ CO$ ______________________________

7. $CaCO_3 \longrightarrow CaO + CO_2$ ______________________________

Balancing Equations

Ordinarily it is not required for water supply personnel to balance chemical equations while working in the field. However, to fully understand the chemical treatment of water, it is important to be able to solve chemical reactions by using equations. Learning to add chlorine to water every three hours is not enough. To know what the chlorine does is necessary. The following equation states, that when you add sodium hydroxide to sulfuric acid, there is a chemical reaction and sodium sulfate (a salt) and water will be formed.

$H_2(SO_4)$	+	$2Na(OH)$	-->	$Na_2(SO_4)$	+	$2H(OH)$
Sulfuric acid		Sodium hydroxide	yields	Sodium sulfate		Water

NOTE: When balancing chemical equations, consult a periodic chart for the valences of each element. Remember, any time a small number (subscript) is used in a chemical formula, it applies only to the element or radical which precedes it. A large number (coefficient) is used in front of an entire compound and applies to everything within that compound. Any time you write a chemical equation, you do not lose or gain a single ion. It is said you can neither create nor destroy matter. Everything you start out with must be found when you complete your reaction. It may be arranged into new or different compounds in the reaction, but the total amount of each element must be equal on both sides of the arrow. Again, a step-by-step procedure is provided to help you balance equations.

An Electromotive Force Series Chart (EMF), figure 3-5, is an aid to solving equations. An EMF series Chart is a grouping of the elements according to their electrical potential or activity. An element will replace any other element listed below it on the chart.

POSITIVE CHART	NEGATIVE CHART
Lithium Li	Fluorine F
Potassium K	Chlorine Cl
Calcium Ca	Oxygen O
Sodium Na	Bromine Br
Magnesium Mg	Iodine I
Aluminum Al	Sulfur S
Manganese Mn	Phosphorous P
Zinc Zn	Nitrogen N
Chromium Cr	Carbon C
Iron Fe	Silicon Si
Tin Sn	
Lead Pb	
Hydrogen H	
Copper Cu	
Silver Ag	
Platinum Pt	
Gold Au	

RULES

1. With reference to the above chart, any element which appears above another element will replace the lower element from its compound.
2. With reference to the above EMF Series, any element which appears below another element will not replace the higher element from its compound.

FIGURE 3-5. Electromotive Force (EMF) Series Chart

Fast Reference for Common radicals and their valences:

(1) $(CO_3)^{=}$ - Carbonate
(2) $(HCO_3)^{-}$ - Bicarbonate
(3) (OH) - Hydroxide
(4) $(SO_4)^{=}$ - Sulfate
(5) $(MnO_4)^{=}$ - Permanganate
(6) $(PO_4)^{=-}$ - Phosphate
(7) $(NO_3)^{-}$ - Nitrate
(8) $(OCl)^{-}$ - Hypochlorite
(9) $(NH_4)^{+}$ - Ammonium

Exercise II-3-d

PART II

Instructions: Write the balanced equation opposite each of the following double displacement equations. In this type of reaction, think of the positive ions changing places in the two original compound. This will result in two new compounds. Include subscripts, coefficients and valences if needed.

a. Silver nitrate + Sodium chloride
$AgNO_3 + NaCl \longrightarrow$ ______ + ______

b. Copper sulfate + Barium hydroxide
$CuSO_4 + Ba(OH)_2 \longrightarrow$ ______ + ______

c. Ammonium nitrate + Sodium hydroxide
$NH_4NO_3 + NaOH \longrightarrow$ ______ + ______

d. Ammonium chloride + Calcium hydroxide
$NH_4Cl + Ca(OH)_2 \longrightarrow$ ______ + ______

e. Sodium hydroxide + Hydrochloric acid
$NaOH + HCl \longrightarrow$ ______ + ______

f. Silver nitrate + Potassium chloride
$AgNO_3 + KCl \longrightarrow$ ______ + ______

g. Copper sulfate + Barium chloride
$CuSO_4 + BaCl_2 \longrightarrow$ ______ + ______

h. Ammonium chloride + Sodium sulfate
______ + ______ $\longrightarrow$ ______ + ______

i. Ammonium sulfate + Calcium hydroxide
______ + ______ $\longrightarrow$ ______ + ______

j. Potassium hydroxide + Hydrochloric acid
______ + ______ $\longrightarrow$ ______ + ______

k. Calcium hydroxide + Sulfuric acid
______ + ______ $\longrightarrow$ ______ + ______

l. Aluminum hydroxide + Phosphoric acid
______ + ______ $\longrightarrow$ ______ + ______

m. Magnesium carbonate + Calcium hydroxide
______ + ______ $\longrightarrow$ ______ + ______

PART III

Instructions: Finish balancing the following single displacement reactions. Refer to the E.M.F., (electromotive force), chart to see if a reaction takes place. If no reaction takes place, write the letters N. R. Equation one is complete. Note that a metal in its element form is neutral in valence.

a. Metallic zinc in a solution of lead nitrate

$Zn + Pb\,(NO_3)_2 \longrightarrow Zn\,(NO_3)_2 + Pb$

b. Lead in a solution of zinc nitrate

________ + ________ → ________ + ________

c. Iron in a solution of copper sulfate

________ + ________ → ________ + ________

d. Copper in a solution of silver nitrate

________ + ________ → ________ + ________

e. Magnesium in a solution of copper sulfate

________ + ________ → ________ + ________

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

The understanding of commonly used chemical terms is essential to the understanding of water treatment. Topics such as solutions, specific gravity, acids, bases, and salts all give us the information so badly needed in this field. Balancing equations consists of making all totals equal, following eight steps or rules in order. Practice in applying these rules will enable you to solve all water treatment results.

LABORATORY SAFETY

OBJECTIVES

Given information pertaining to laboratory chemicals, identify the statements corresponding to their use and care as true or false. Three of the five answers must be correct.

Given a list of ten statements pertaining to the use and care of laboratory equipment, match the identifying statements to the correct piece of equipment. Seven of the ten answers must be correct.

INTRODUCTION

The work of a laboratory technician in water treatment can be safe if you will use a few simple precautions when mixing chemicals, handling glassware, and operating equipment. Accidents do not just happen; they are caused by unsafe acts or conditions. The skilled operator must know the proper chemicals, the proper method of mixing chemicals, the correct names of the equipment, and the importance of keeping your mind on the work. The last is very important. Many times after an accident, victims have remarked, "I was not thinking." Information of importance to you in gaining an understanding of how accidents are caused and prevented is presented in this study guide. However, not all of the information you need to know is contained here. Additional study on this subject is recommended. The topics in this chapter will be presented as follows.

* Handling Acids, Alkalies, and Other Chemicals
* Laboratory Glassware
* Laboratory Safety Equipment
* Do's and Don'ts of Laboratory Work

INFORMATION

Handling Acids, Alkalies, and Other Chemicals

Acids and alkalies can cause severe burns when they come in contact with the skin. When handling chemicals, never put your hands to your eyes or face without first washing them. The skin tissue of your face is more sensitive and is more easily irritated than the skin of your hands. Rubber gloves must be worn when handling large amounts of concentrated acids to protect your hands. You must wear a rubber apron to protect your clothes. Before using these protective devices, they should be inspected to assure they will give the protection for which they were made. When mixing acids with water, the acid should be slowly poured into the water and the solution should be constantly stirred with a glass stirring rod to prevent a concentration of the acid in a small area of the water. Failure to follow this procedure may result in the acid boiling and splattering the surrounding area, causing severe burns to the worker. Never pour water into acid. Should any of your co-workers get a spray of acid in the face or eyes, do not let that person put their hands to their face. Instead, immediately place that person under a shower where plenty of water can wash away the acid. Then take the injured person to the hospital for treatment. A helpful addition to any laboratory is a container of water and baking soda. This will neutralize the acid in case of an accident.

Other chemicals used in the laboratory are also hazardous and must be handled with care. In addition to burns, chemicals may also be poisonous. The poison can be taken into the body orally, through skin exposure, or by breathing vapors. All chemicals should be considered poisonous whether they are labeled as such or not.

Laboratory Glassware

Before using any glassware for testing water, an inspection of the article should be made for cracks and rough edges. Never work with broken or cracked glassware. When heating a liquid in a beaker or flask, always apply the heat gradually. A large amount of heat concentrated in a small area can set up a strain on the beaker or flask that might cause it to crack. Also, never heat a closed container. If a piece of glassware should break or be damaged when you are using it, stop the procedure and start over with another piece of equipment. Dispose of the broken glassware properly so that it will present no further hazard.

Laboratory Safety Equipment

Although some differences will be found in safety equipment which has been provided for use in the water testing laboratories, most laboratories will have similar items of safety equipment.

1. Rubber aprons are provided and will be worn whenever you are working in the laboratory.
2. Heat resistant gloves are used when removing hot samples from a muffle furnace. Several types of tongs are also available for hot samples, and may be used for handling equipment which cannot be picked up with your bare hands.
3. An emergency shower and a special eye washer should be near the laboratory working area to provide clean water for rinsing oneself in case of chemical spills. An operational check at regular intervals should be made on both pieces of safety equipment to insure proper operation.
4. Properly equipped laboratories must be well ventilated. Exhaust fans will provide for quick removal of toxic or noxious fumes.
5. Walkways in the laboratory should be covered with rubber floor mats to lessen the chance of slipping and falling. They also act as an electrical insulator and decrease the possibility of receiving an electrical shock when operating electrically powered machines.

Do's and Don'ts of Laboratory Work

1. Always try and keep a blue color flame on your Bunsen burner. This is done by allowing enough air in through the vents. Do not allow the tubing to become twisted. You could burn the tube and thus allow gas to escape which could lead to an explosion. Also, remember to light your match first and then turn the gas on.
2. Never allow the steam bath to burn dry, and never leave boiling samples unattended.
3. Always use heat resistant gloves and long tongs when working with the muffle furnace.
4. Never put a sample straight from the muffle furnace into the desiccator. Such heat differences could cause the desiccator to crack.
5. Always make sure the indicating dial on the analytical balance is in the zero position (off) before you put a sample in or take a sample out.
6. Never use excessive pressure to unstop the valve on a burette.
7. Always remove all jewelry before entering the laboratory area.
8. Never take deep breaths of chemical to identify their contents.
9. Never "experiment" with mixing of chemicals or lab materials.
10. Immediately wipe up spills to prevent skin and clothing contamination.

SUMMARY:

Do not forget that most accidents can be prevented. Your part in safety programs is to become familiar with the causes of accidents and to follow the prescribed rules and precautions to prevent them. Some of the conditions which cause accidents are poor housekeeping, horseplay, improper use of equipment and noncompliance of warning signs. Pay attention to the safety procedures while working with laboratory equipment, and the accidents will be prevented.

Exercise II-4-a

Instructions:

1. What type of injury may result from contact with acids or alkali?

2. What chemical is a safe antidote for acid burns?

3. List five items of safety equipment which should be available in water testing laboratories.

4. When should personnel put on a rubber apron?

5. Safety in the laboratory is the responsibility of whom?

6. In what two conditions should you never use a piece of glassware?

7. You should remove what when entering the laboratory area?

8. List three good practices and three bad practices while working in the laboratory area.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

Exercise II-4-b

Instructions: Place the letter indicating the correct term in the blank preceding the statement in Column I. Each answer in Column II may be used once, more than once or not at all.

COLUMN I

1. ( ) Used to transfer exact quantities of liquid reagents
2. ( ) Used to measure a reagent while titrating a water sample
3. ( ) Used to evaporate water samples under controlled conditions
4. ( ) Used to measure exact amounts of water samples
5. ( ) Used to volatilize organic matter
6. ( ) May be used as a container when heating samples over a burner
7. ( ) Used to heat samples
8. ( ) Used to measure temperature
9. ( ) May be used to contain sample being titrated
10. ( ) Used to weigh samples during gravimetric analysis
11. ( ) Container in which "solids" samples are placed to cool
12. ( ) Used to measure exact volumes of dry powder
13. ( ) Used to stir samples during titration
14. ( ) Container for sample which is swirled during titration
15. ( ) Used for biochemical oxygen demand test
16. ( ) Used when mixing or testing solutions

COLUMN II

a. Bunsen burner
b. graduated cylinder
c. pipette
d. dessiccator
e. burette
f. casserole
g. glass rod
h. Erlenmeyer flask
i. steam bath
j. beaker
k. analytical balance
l. thermometer
m. chemical dipper
n. muffle furnace
o. reagent
p. evaporating dish
q. incubator

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

COLLECT WATER AND WASTEWATER SAMPLES

OBJECTIVES

Given information, the appropriate sampling device and a maximum of one instructor assist, collect and label a water sample to test for various impurities.

Using given information, and a maximum of one instructor assist, list the procedures required for collecting a sample of wastewater and sample of sludge.

INTRODUCTION

The collection of water samples and the care given the samples before they reach the water testing laboratory are very important. The biggest problem in the collection of water samples is to collect samples which are truly representative of the water from which they are taken. Frequent chemical analysis of both raw and treated water are commonly made to plan and control treatment and to insure that the water is satisfactory for industrial purposes, or that it is safe and potable to drink. Water and wastewater processing specialists are responsible for the collection of water samples from many sources, and may also be responsible for the collection of samples from the wastewater processing plant on base. The information on the collection and care of water samples will be included under the following main topics.

* Purpose of Water Sampling
* Procedures used in Collecting Water Samples
* Dissolved Gas Samples
* Samples for Bacteriological Analysis
* Labeling Water Samples
* Purpose of Wastewater Sampling and Types of Samples
* Procedures Used in Collecting Sludge Samples

INFORMATION

Purpose of Water Sampling

The collection of water samples is a preliminary step to water testing. The purpose of water sampling is to obtain representative samples in order that water tests may be performed. The water tests may be required for a variety of reasons. Included are tests to find the kind and amount of impurities, the treatment needed, if the treatment is working, if the correct amount of chemicals are being used, and last and probably most important, to determine if water is safe for the purposes which it will serve.

Procedures Used in Collecting Water Samples

Collecting samples from the ground (raw) - The procedures for collecting a raw water sample from a well that is equipped with a pressure pump are as follows:

1. The point of sampling should always be as close to the source as possible.

2. The most desirable points of collection are either from the pump housing itself or from the discharge line as close to the pump as possible. A small rubber hose connected to a short piece of copper tubing and a valve is satisfactory for a sampling line.

3. Always flush out the sampling line before you take the sample.

4. Use only clean containers to collect water samples. It is a good practice to always rinse container and its cover with some of the sample water before taking samples.

5. Cap the container immediately after you draw the sample to avoid contamination.

6. Label the sample.

7. Test as soon as possible.

Collecting samples from the surface (raw) - Surface water usually means water from a lake, stream, or spring. It is difficult to say exactly where the point of sampling point should be because of the varied conditions of surface water. You need to use good judgment and reasoning to select the sampling point where the water is most representative. You should never take a sample from a lake or stream at or near the inlet, a stagnant pool, along the shore, or near the surface. To obtain a sample from a lake, stream, or spring, thoroughly rinse the container and then submerge and uncork the container beneath the surface. When the container is full, put the cork back in and withdraw the sampler from the water. This procedure will help prevent contamination of your sample by other undesirable levels of water.

Dissolved Gas Samples

Take samples for dissolved gas tests carefully. Use special apparatus to prevent changing the gas content of the sample by contacting it with the air. Use narrow mouth eight ounce bottles with glass stoppers. Testing should be conducted as soon after collection as possible or within one hour.

Samples for Bacteriological Analysis

In obtaining samples for bacteriological analysis, contamination of the sample bottle, stopper, or the sample itself may cause potable water supplies to be reported as nonpotable. Full compliance with the following precautions is necessary to assure the correct analysis.

1. Bottles: use only clear, sterilized bottles with glass stoppers.

2. Sampling from a Tap: After testing for Cl_2 residual, close the tap and heat the outlet to destroy any contaminating material that may be on the tip of the faucet. Flush tap long enough to draw water from the main source. Remove stopper, but do not touch the bottle mouth or the sides of the stopper. Fill the bottle three fourths full; this is done to leave room for the chemicals you will add during the tests. Replace the cap and fasten the protective cover with the same care.

3. Sampling from Tanks, Pools, Lakes or Streams: When you collect samples from standing water, remove the stopper as above and plunge the bottle, mouth down, at least 3 inches beneath the surface. Fill the bottle by moving it away from your hands so the water that has contacted your hands does not enter the bottle. Discard one quarter of the water and replace the stopper. To collect samples from swimming pools, collect the sample from the side of the pool near the deepest part. Take the sample while the pool is in use, preferably during the heaviest bathing load. To collect samples from lakes and ponds, take the samples from a boat or pier about 25 feet from shore and in water at least 4 feet deep. Do not collect samples at the shoreline. Collect stream samples from a point where water is flowing, not from a stagnant pool. In a meandering stream, collect a sample at a point where flow velocity is normal.

Labeling Water Samples

Water samples are of little or no value unless they are properly identified. Many times samples lose their identity while being transported from the point of collection to the point of testing. If the containers are properly labeled, there will be little chance of a mix-up. Properly labeled water samples also aid you when you fill out the reports as you test the water. The information required to be written on the label varies, but usually includes name of the collector, temperature, source, date of sample, and the type of analysis needed.

Purpose of Wastewater Sampling and Types of Samples

The purpose of wastewater sampling is to get a representative part of the wastewater so that tests may be made to find the composition and characteristics of the flow. Samples must also be obtained to determine the effectiveness of treatment and to find out whether or not there is a need for a change in treatment.

Types of samples - Wastewater is made up of 99.9 percent water and 0.1 percent solids. This 0.1 percent consists of both organic and inorganic matter which may be dissolved, or may be in a suspended condition with varying characteristics. The solids tests that you make will give you a good idea of how the wastewater should be treated. Before the tests can be made you must collect representative samples of the flow. Waste samples are grouped into two general types depending upon the manner in which the samples are taken.

The two types of samples are grab samples and composite samples. Grab samples are taken at one point at one time. This type of sample is very important when the condition of the raw wastewater must immediately be known. They tell you the condition of the wastewater at that time only. Very often it is necessary to alter operations slightly to take care of an immediate, temporary problem. Grab samples will tell you when rapidly changing situations occur. A grab sample would not however, help you much if you wanted to know the average wastewater condition. You will generally take grab samples for the following tests: dissolved oxygen (D.O.), pH, chlorine demand, chlorine residual, settable solids, and temperature. They are also used to determine the concentration of mixed liquor and the concentration of sludge in "activated sludge processes."

Composite samples consist of individual samples taken at regular intervals over a selected period of time and then thoroughly mixed prior to testing. We might say that a composite sample is made up of several grab samples taken at one place, but many times during a certain period of time. Remember, the same amount of time is allotted between each new sample when making a composite. This sample may be mixed after the addition of each individual sample, or at the end of the sampling period. Raw wastewater samples are collected hourly unless special studies or tests are being made. The volume of individual samples taken should be in proportion to the volume of wastewater flow at the time the sample is taken. The sample may be kept in a wide mouthed, stoppered glass bottle, or covered enamel pails, which must be kept refrigerated until they are tested. This helps to slow down the rate of decomposition of the wastewater. The usual sampling period is 24 hours, although shorter periods may be used. Composite samples are necessary when planning the overall operation of the wastewater treatment plant. A composite sample is generally taken to determine suspended solids, total, volatile, fixed solids of sludge, grease, and the biochemical oxygen demand (B.O.D.) of wastewater.

Procedures used in Collecting Sludge Samples

Composite sludge samples should be taken from raw sludge going to a digester and digested sludge going to the drying beds. Samples should be individually collected at regular intervals over the pumping or drawing off period. Space these intervals to provide for the collection of at least five or six individual samples over a certain period. The composite sample must represent all pumping periods for the entire day. Sludge samples may be taken from a digester with a device shown in figure 5-2. Its use in the sampling hole of a digester is illustrated in figure 5-3. The chain is marked to indicate depth of one-foot intervals. Collect samples of digester sludge at intervals of 3 to 5 feet, starting at the top and working down. This will avoid agitating the lower sludge from which the next samples are taken. Pour each sample into a wide mouth bottle, appropriately marked, and rinse the sampler thoroughly before the next sample is taken. A pitcher pump with a hose marked at one foot intervals may also be used. A checklist is provided below for you to follow when taking sludge samples.

Checklist

Sludge Sampling Procedure

1. Lower a bacon bomb sampler through the sampling compartment on the top of the digester.

2. At 3-5 foot intervals pull the chain that opens the sampler allowing sludge to flow into the device.

3. Remove sampler and pour the sludge into a container that is properly labeled.

4. Repeat Step 1, but lower the sampler 3-5 feet deeper than the last sampling point. Keep repeating this process until you reach the bottom of the digester.

SUMMARY

A water sample should be collected so that it represents what is supposed to represent. It should not be diluted, concentrated, or contaminated before testing. Samples should be labeled so that they do not become mixed up and so that the report may be sent to the right place.

Measuring the impurities in wastewater is very important in the operation of a wastewater treatment plant. To be able to make these measurements, it is necessary to be careful in both collecting the sample and in making the test.

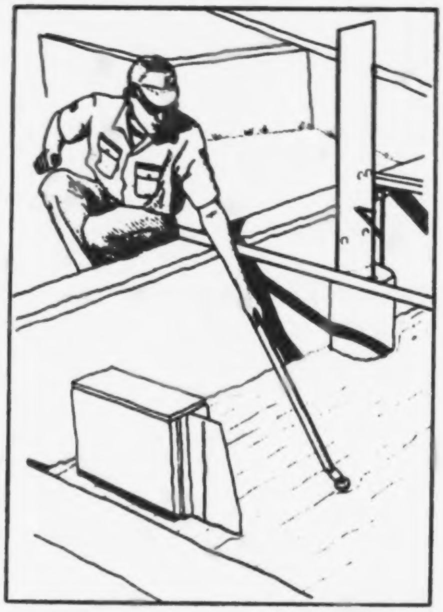


FIGURE 5-1 - Sampling from a Tank Ahead of the Weir

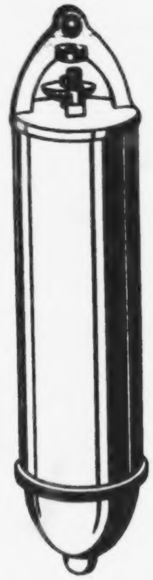


FIGURE 5-2 - Sludge Sampler

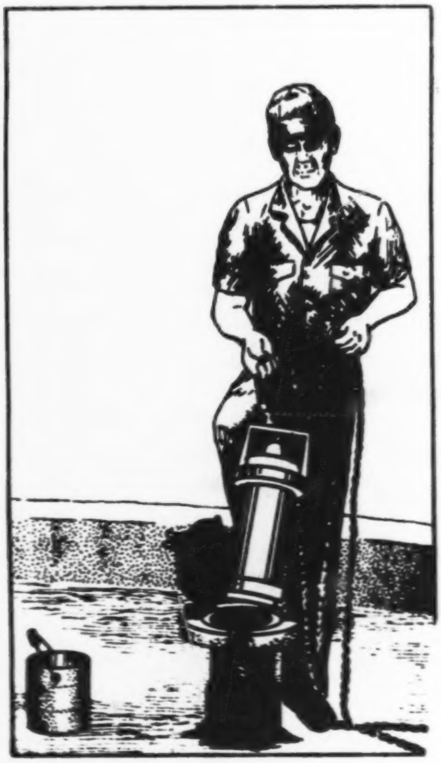


FIGURE 5-3 - Collection of a Sludge Sample from a Digester

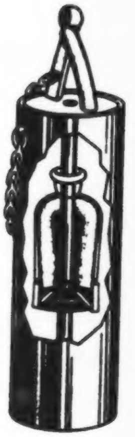


FIGURE 5-4 - Dissolved Oxygen Sampler

Exercise II-5-a, b

PART I

Instructions: Complete the following questions which pertain to water and wastewater sampling. Because of the closely related subject matter, both water and wastewater objectives may be completed as one subject.

1. What is the biggest problem in obtaining a water sample?

2. What type bottle is used as a container for a water sample?

3. Name two precautions which should be observed to prevent a water sample from becoming contaminated by the atmosphere.

4. Why should samples be labeled as soon as they are taken?

5. What items are usually required on a water sample label?

6. Where should a water sample be taken from a water supply well?

7. Where would be a good place to collect a water sample if your source is a lake?

8. What are grab samples? Composite samples?

9. Which tests require composite samples/grab samples?

10. What type bottle is used along with the sampling device to collect samples for the D.O. test?

11. It is essential to use what type of containers for a bacteriological analysis?

12. What is the recommended level to fill bottles for a bacteriological analysis, and why do you do it this way?

13. Where are samples taken from flowing wastewater?

14. Name three collection points when taking a grab sample of sludge.

15. What device is used to take a sludge sample?

PART II

Instructions: Following written instructions collect and label a water sample from a given source which could be used to test for dissolved gases. Sample will be taken from an area designated by the instructor.

1. Collect a water sample
   a. Obtain a clean water sample bottle from the lab
   b. Go to sampling point designated by the instructor
   c. Open tap and allow water to flow long enough to draw water from main before collecting sample.
   d. Rinse sample container with some of the sample water.
   e. Attach rubber hose to tap and let water flow until all air is removed from hose.
   f. Drop end of hose to bottom of sample bottle and using a slow, steady flow, fill sample bottle to overflowing.
   g. Turn off tap and immediately cap sample bottle.
2. Label sample giving the following information:
   a. Name of collector
   b. Date of collection
   c. Temperature
   d. Source
   e. Type of analysis needed

PART III

Instructions: List the step by step procedures for collecting and labeling a wastewater sample. Use AFM 91-32 as a reference.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________

PART IV

Instructions: List the step-by-step procedures for collecting a sludge sample.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

9. ______________________________

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

WATER ANALYSIS

OBJECTIVES

Using appropriate laboratory equipment and testing procedures, test various samples of water for pH, temperature and specific conductance.

Using apropriate laboratory equipment and testing procedures, test various water samples for chlorine residual, turbidity, iron and fluoride.

Given laboratory equipment, HACH DR 3000 Spectrophotometer Methods manual, and a water sample, test the sample for true color with no more than one instructor assist.

Given information, laboratory equipment and various water samples, test the samples for hardness, acidity, and alkalinity.

Given the types of phosphate compounds, and a list of statements pertaining to phosphates, match each type of compound to the statement to their purpose and their usefulness. Three of the five selections must be correct.

Given five incomplete statements concerning chloride compounds, complete the statements as they pertain to the compound type, source and testing procedures. Three of the five completed statements must be correct.

INTRODUCTION

The purpose of this chapter is to help you understand and become familiar with water analysis and the importance of how and why the tests are performed. Correct information gathered from water samples is necessary to monitor the plant efficiency and plant effluent. Federal and state standards must be met. Test results advise the operators of problems and let them use prompt corrective actions. Records of test results are kept on file to show a history of operations and problems within the system.

For domestic purposes, water tests may be related to the protection of property such as corrosion to metals or scale deposits. Naturally, the welfare of the consuming population is well considered. The US Department of Health and Human Services and other agencies have set water quality standards and are the inspecting and controlling agencies to ensure our water is safe to use. Water analysis and documentation is a must. Some of the important tests to analyze in this group are pH, acidity, total and calcium hardness, although the determination of conductivity and total solids may be included.

Water takes on various characteristics and properties as it passes over and through the earth. These characteristics and properties vary and are dependent on the materials encountered. They may be classified according to means of detection: physical (detected by one or more of the five senses), and chemical (detected by chemical analysis). The most important physical characteristics are turbidity, color, odor, taste and temperature. The most important chemical characteristics are acidity, alkalinity, and hardness. Sometimes these two types of characteristics overlap, for example: iron in water is a dissolved mineral detectable by chemical analysis, yet its color and taste are by physical analysis.

CLASSIFICATION OF NATURALLY OCCURRING WATER SUPPLIES

Surface Water

For convenience, naturally occuring surface water supplies may be divided into three primary categories: fresh water, brackish water, and salt or sea water.

Fresh Water. Fresh water includes flowing streams or rivers and water impounded by lakes or reservoirs. Most of the surface waters in the United States is fresh water. Air Force standards permit maximum chlorides of 250 ppm (parts per million), maximum sulfates of 250 ppm, and maximum total dissolved solids of 500 ppm.

Brackish Water. Brackish water is found in many regions throughout the world, but occurs most frequently as ground water in arid or semiarid climates. Brackish water is highly mineralized and contain dissolved solids in excess of 500 ppm. This makes it objectionable as a drinking water supply. Total dissolved solids may be as high as 15,000 ppm. Both alkalinity and salinity range from very high to very low.

Salt or Sea Water. Salt or sea water usually contains total dissolved solids above 15,000 ppm. This is an approximation since no clear-cut line of distinction can be drawn between brackish and salt water. Typical salt water has a very high sodium chloride content and a low alkalinity. It is generally found only in a free body of water such as ocean, sea or estuary. The most abundant source, the oceans, may contain total dissolved solids up to 35,000 ppm. Inland seas such as the great Salt Lake may have total dissolved solids of 200,000 ppm.

Ground water

Ground water is made up of all water found beneath the surface of the earth. To tap this source of water, a digging or drilling of a well must be accomplished. The depth of the well depends on several factors, chiefly the depth of the water table. More information on wells will be covered in Block 3.

PHYSICAL CHARACTERISTICS

Conductivity

Conductivity is the ability of a substance to carry an electric current. Resistivity is the term used to describe the efficency a substance can conduct the electric current. Before the advent of sophisticated modern-day equipment, the resistivity of an object was measured by applying a current of known voltage to that objective buried in a box of fullers earth (called a conductivity box) and measuring the amount of voltage that traveled one centimeter across the substance. The difference of the two voltages was measured in either ohms or micromhos. The greater the ohms or micromhos, the greater the conductivity and the smaller the resistivity. The smaller the ohms or micromhos, the smaller the conductivity and the larger the resistivity. In water testing the unit of measurement is micromhos/cm. The 'cm' denotes the distance the electric current traveled. Instruments used today can measure conductivity without burying in a conductivity box.

Water which has been treated to remove all ions except HOH, will not conduct electricity. However, if ions are added to this water, it's conductivity will increase in proportion to the amount added. The amount of ions in water is referred to as total dissolved solids. Thus, the more micromhos/cm water has, the more total dissolved solids it has.

The most common use of this test is in determining the quality of distilled or demineralized water. The less the total dissolved solids, the higher the quality water.

In the classroom we will be measuring various samples of water using two different types of conductivity meters. The ions or total dissolved solids (TDS) we will measure are sodium chloride crystals or salt. Follow the instructions in your lab manual and directions from the instructor.

Turbidity

Turbidity is a muddy or unclear condition of water, caused by suspended particles of sand, silt, clay or organic matter. As water goes through the hydrological cycle, it picks up impurities of dust, smoke, silt, minerals and disease organisms. Turbidity is a suspended solid that can be detected by one or more of your five senses. Also, the faster water flows, the more material it picks up and the larger the size of the pieces carried along. As water slows down, the larger particles settle out. When the flow stops, all but the finest particles settle out. Clay and silt remain suspended in water the longest because the particles are so small.

The removal of turbidity is essential in the production of potable water. Such removal reduces contamination, extends the time between backwashing of filters, decreases chlorine demand, improves disinfection and improves the acceptability of the finished water. The Air Force Medical Service requires turbidity removal because suspended particles often contain disease-producing organisms.

For the most precise turbidity measurements, a laboratory turbidimeter is recommended. This is a true Nephelometer which meets the turbidity measurements described in APHA Standard Methods and other EPA approved publications. The unit mentioned above is used in our lab and requires extreme care when in use. Turbidity is measured in turbidity units, Nephelometer Turbidity Units (NTU).

Color

Color in water may be due to dissolved, colloidal, or suspended solids. It may be measured as apparent color or true color. Apparent color (as it appears to the eye) is measured before removal of suspended solids, by filtration. True color is the color after filtration. Most color problems in raw water supplies are due to vegetable dyes from decaying organic matter or colloidal precipitates of iron and manganese. Industrial wastes may produce special color problems. These should be prevented or treated at the source. Color as such is harmless but will be objectionable from the standpoint of appearance and may be associated with taste and odor problems. No one treatment method will remove all colors and no rule will apply to all waters.

Odors and Taste

Taste and odor found in water are caused by algae (small aquatic plants), decomposing organic matter, dissolved gases, or industrial waste. Mineral substances may also be a cause. The chlorination of water may produce odors and tastes of its own or increase those of the responsible organisms through destruction. Potability is not normally affected by the presence of odors and tastes. On the other hand, palatability is frequently affected, particularly when an agent such as bone or fish oil is present. Water containing one of these agents in noticeable quantities is unpalatable.

Temperature

Temperature is a physical characteristic which is many times not controllable by the water treatment operator. However, problems which are temperature related can be anticipated by the operator and any changes in operation, if possible, can be initiated.

In the summertime the water temperature of deep lakes and reservoirs changes sharply from the top to the bottom surfaces. Due to the differences in density of water at different temperatures, cold water will rise up to the top, usually bring up sediment from the bottom. This causes a higher intensity of taste and odors. In the wintertime, water at temperatures of less than 45°F will slow down reaction times on many chemicals causing a reduced treatment rate. Overall water is usually easier to treat at a cool temperature due to the simple fact that it tastes better cool.

CHEMICAL CHARACTERISTICS

Hardness

The total amount of solids in water depends upon the material with which it has been in contact, the length of exposure and the amount of carbonic acid present. Hardness results from the presence of soluble salts of alkaline earths. The most common alkaline earths are calcium and magnesium. Hardness is undesirable in that it consumes soap, and produces scale in boilers and distillation units.

Iron

Iron may be found in water supplies as soluble or insoluble compounds. It is more common in well water than in surface water. Water low in dissolved oxygen converts iron from the insoluble state to the soluble state. In the soluble state, the mineral is colorless. When the iron comes into contact with air during pumping or aeration activities, the iron will convert to an insoluble form. Iron is undesirable because it imparts a rusty color and objectionable taste to water. It also forms crust in plumbing and piping. When iron is present in water, bacteria may also be present. One of the most common type bacteria that develop in water that has iron is "Crenothrix". This type bacteria needs iron for food and lives in the dark and will not grow well when there is a lot of dissolved oxygen. If these bacteria should die due to poor living conditions, they will create bad tastes and odors in the water. The precipitation of iron and dead bacteria will also cause clogging of pipes. The removal of iron from the water and the increase of dissolved oxygen by aerating the water will prevent the growth of Crenothrix. The total iron concentration in potable water should not exceed 0.3 milligrams per liter.

Manganese

While not encountered as often as iron, it is found in both surface and ground water. Its presence in water normally causes a gray or black color. The total concentration of manganese in potable water should not exceed .05 milligrams per liter.

Chlorides

Chlorides ions can sometimes be found in water sources. They can be the result of natural contamination by way of coastal infiltration of salt water, or as a result of man-made contamination from wastewater or ion exchange discharges. Chloride concentrations of over 250 mg/L will impart a salty taste in the water, while chloride content over 30,000 mg/L will cause sickness to the consumer. Three common chloride compounds found in drinking water include $MgCl_2$, $CaCl_2$, and NaCl.

pH

Literally, pH stands for "power of hydrogen". The amount of H^+ ions in a water sample is, through a mathematical formula, translated to a scale from 0 -14. Below is an example of the pH scale.

Acid — Neutral — Base
0 ———————— 7 ———————— 14

It is important to remember, however, that pH is NOT a measure of the amount of acid or akalinity, but merely the tendency of the water to be either corrosive or not.

Acidity/Alkalinity

The amount of acid compounds and alkaline compounds represents an important test series in water treatment. Acidity and alkalinity are exact opposites of each other. Acidity is the ability of water to neutralize a strong base and alkalinity is the ability to neutralize a strong acid. Most times natural waters of the surface type have an amount of alkalinity while waters found in the ground usually have a small amount of acidity.

Three ions make up alkalinity in the water: OH^-, $CO_3^=$, and HCO_3^-. OH^- is not found naturally in raw waters but is used in various water treatment processes. If found in raw water sources, OH^- indicates that a pollution source is discharging into the water. $CO_3^=$ and HCO_3^- are both found naturally in water sources and they too are used in various water treatment processes. Alkalinity can be found in the water from a pH of 4.5 to 14 pH.

Acidity is made up of the free mineral acids, ie., HCl, H_2SO_4, H_3PO_4, and HNO_3, and the carbonic acids made up of H_2CO_3. Free mineral acids, FMA, are not usually found naturally and exist in water with pH from 0 - 4.8 pH. Carbonic acids, usually caused by CO_2 gas dissolved in water forming H_2CO_3, can be found in water up to an 8.3 pH.

For proper treatment of water to occur, a balance must be maintained between acidity and alkalinity. This balance is achieved by the addition of chemicals to the treatment process. Without accurate test results, however, this balance will be impossible to accomplish, illustrating the importance of lab work.

Fluorides

Fluoride is a mineral that many municipalities have decided to add to their water systems. Through numerous studies, fluorides have proven to prevent dental cavities in children through age 12. Fluorides are not without critics, for some feel that fluoridation of water is unhealthy. Use of fluoride, however, has been approved by the

Phosphates

Phosphates are mostly found in soaps and fertilizers. If you look at the box of any laundry detergent, it will state the percent of phosphates it contains. The higher the amount of phosphate, the more powerful the detergent and the more it will polute. Remember, phosphates will not decompose naturally. Phosphates come in two parts, ortho-phosphates and poly-phosphates. Ortho-phosphates are used to soften water for domestic and industrial uses. Poly-phosphates are used to stablize water after it has been treated. Stabilization will prevent corrosion and scale in our water lines and machinery. Each type in small quantities serves a useful purpose. We can only make tests for ortho-phosphates. So we must change all poly-phosphates in a sample to ortho-phosphates by heating.

Chlorine

Chlorine is a major disinfectant used for both water and wastewater. While it is not known how chlorine kills bacteria, what is known is that when chlorine is present in water, known as chlorine residual, bacteria can not exist. This fact is very useful for assuring a drinking water system is safe for consumption. A 0.2 ppm reading is considered potable (safe to drink).

DISSOLVED GASES

The concentration of a gas in the water is directly proportional to the concentration and pressure of that gas in the atmosphere. In general, this involves the water temperature, its salinity and altitude. The gases of primary interest to water supply are listed below.

Oxygen

Large amounts of dissolved oxygen are found in rain water. The amounts in surface water vary greatly depending on the amount and type of pollution, the degree of self-purification, the action of algae and the temperature of the water. Polluted water will exhaust the dissolved oxygen supply, while cleaner water will maintain a greater dissolved oxygen supply. Colder water contains larger amounts of dissolved oxygen than warmer water. As the temperature rises, the dissolved oxygen is released to the atmosphere. Decreased pressure on water has the same effect, releasing oxygen to the atmosphere. One disadvantage of a high dissolved oxygen content is that it will cause many metals to corrode. Figure 6-1 shows a D.O. sampler.

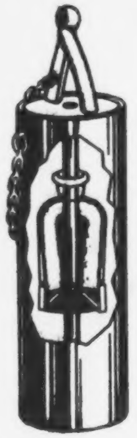


FIGURE 6-1. Dissolved Oxygen Sampler

Carbon Dioxide

The presence of carbon dioxide in water contributes to the degree of hardness and acidity of the water. Water acquires this gas in four ways: from the air by natural movements of water coming in contact with the air, such as currents and wave action; by contact with decomposing vegetation, which gives off carbon dioxide freely; by the reaction of alum and soda ash in the coagulation process; by contact with the gas in underground deposits. A high carbon dioxide content usually makes water more corrosive to metals.

Hydrogen Sulfide

Hydrogen sulfide in solution lends a disagreeable taste and rotten-egg odor to water. Ground water absorbs sulfides by passing over sulfur bearing rocks. Hydrogen sulfide is also responsible for the destruction of cement and concrete as well as the corrosion of metals. In small amounts it is unpleasant but not dangerous. In large amounts it is harmful.

SUMMARY

Water takes on its own physical and chemical properties as it passes over and through the earth. Some of these properties can be in the form of turbidity, color, odor, taste, temperature and dissolved minerals. Surface and ground water are two supply sources for our use. Surface water is divided into three categories, fresh, brackish and salt water. Some characteristics of water are hardness, acidity and alkalinity. Oxygen, carbon dioxide and hydrogen sulfide are common dissolved gases found in our water source today.

Exercise II-6-a

PART I

Instructions: Complete the following list of questions with full explanations.

1. What are some distinguishing properties and characteristics of water?

2. What are the two sources of water?

3. What is meant by "brackish" water?

4. Explain why hydrogen sulfide gas is found in some of our water.

5. What will the effect of an excessive amount of manganese do to our water supply?

6. List the two elements that are undesirable in that they cause a high soap consumption.

7. What are two types of phosphates used in water treatment?

8. What test measures the TDS content of water?

Exercise II-6-b

Instructions: Fill in the blanks with the correct response to make each of the following a true statement.

1. Colorimetric method of testing is used to test for _________ __________, __________, __________, __________, and __________.

2. __________ does not occur naturally, but is added to kill bacteria. Potable water may have a residual of __________ ppm.

3. Iron is objectionable at __________ ppm.

4. __________ is added to help prevent tooth decay. The most desired amount is __________ ppm. 3 to 5 ppm causes __________ __________.

PART II

Instructions: Given a set of facts concerning the testing of water for temperature, pH, and specific conductance, correctly match each fact with its statement. Place the letter indicating the correct term in the blank preceding the statement in Column I.

COLUMN I	COLUMN II
1. ( ) pH	a. neutral
2. ( ) TDS	b. parts per million
3. ( ) mg/L	c. polarization
4. ( ) mL/L	d. standardize the pH meter
5. ( ) standby position	e. prepare the meter
6. ( ) to determine kind of treatment required	f. hydrogen ion concentration
7. ( ) buffer solution	g. grains per gallon
8. ( ) uncover probes	h. acid
9. ( ) pure water should have a pH of ________	i. base (alkaline)
10. ( ) ppm	j. electric meter
11. ( ) gpg	k. purpose of water analysis
12. ( ) use of low range probes	l. C° and F°
13. ( ) use of high range probes	m. purpose of specific conductance
14. ( ) method used to test for pH and conductance	n. H+ ions
15. ( ) pH = 7	o. OH-ions
16. ( ) pH = 9	p. milliliter per liter
17. ( ) pH = 4	q. milligram per liter
18. ( ) acidity	r. demineralizers
19. ( ) alkalinity	s. raw or treated water
20. ( ) two scales which temperature can be measured by	t. pH = 7

EXERCISE II-6c

1. Two types of color are ______________________ and ______________________________.

2. ________________ color is caused by __________________ solids such as vegetable matter and algae.

3. ________________ color is caused by __________________ solids such as iron and maganese.

4. ________________ color cannot be removed by filtration.

Exercise II-6-d

Instructions: Fill in the blanks with the correct response so that each statement will be true.

1. Two types of phosphates are ____________ and ____________.
2. Phosphates are found in ____________ and ____________.
3. We can only test for ____________.
4. We change all ____________ to ____________ by heating the sample.
5. ____________ will prevent corrosion in our water lines.

Exercise II-6-e

PART I

Instructions: Under the general clasifictions of impurities listed below, list the causes of each impurity.

HARDNESS	ACIDITY	ALKALINITY	CHLORIDES
(1) ____________	(1) ____________	(1) ____________	(1) ____________
(2) ____________	(2) ____________	(2) ____________	(2) ____________
(3) ____________	(3) ____________	(3) ____________	(3) ____________

PART II

Instructions: List the following compounds in the correct columns in the table below.

a. NaOH
b. $CaCl_2$
c. H_2SO_4
d. KOH
e. $MgCO_3$
f. $CaCO_3$
g. $NaHCO_3$
h. $Fe(HCO_3)_2$
i. $CaSO_4$
j. $MgSO_4$
k. Na_2CO_3
l. $MgCl_2$
m. HCl
n. $Ca(HCO_3)_2$
o. $Mg(HCO_3)_2$
p. $Mn(HCO_3)_2$

Compounds causing hardness alone

Compounds causing both hardness and alkalinity

Compounds causing alkalinity alone

Compounds causing acidity

PART III

Instructions: List the following compounds in the correct column in the table below.

a. NaOH
b. $CaCO_3$
c. KOH
d. $CaSO_4$
e. Na_2CO_3
f. $Ca(HCO_3)_2$
g. $CaCl_2$
h. $MgCO_3$
i. $NaHCO_3$
j. $MgSO_4$
k. $MgCl_2$

Compounds causing hardness alone	Compounds causing both hardness and alkalinity	Compounds causing alkalinity alone

PART IV

Instructions: The following chart gives the relationship between "P" alkalinity and "M" alkalinity. Using the chart, solve problems 1 thru 10 and list your answers on the blank lines. You are to determine the amount of alkalinity (OH, CO_3 and HCO_3) and concentration present.

Condition of alkalinity	Hydrate OH	Carbonate CO_3	Bicarbonate HCO_3
P=0	0	0	Same as M
P=M	Same as M	0	0
P=1/2M	0	Same as M	0
P is more than 1/2M	2p-M	2(M-P)	0
P is less than 1/2M	0	2P	M-2P

1. When the total alkalinity (M) is 40, and P is also 40 ppm. ____________________
2. When M = 60 ppm. and P = 30 ppm. ____________________
3. When M = 25 ppm. and P = 0 ppm. ____________________
4. When M = 40 ppm. and P = 10 ppm. ____________________
5. When M = 50 ppm. and P = 30 ppm. ____________________

PART V

Instructions: The following chart gives the relationship between hardness and alkalinity. Using the chart, solve problems 1 thru 10 and list your answers on the blank lines. You are to determine the amount of carbonate hardness and the amount of non-carbonate hardness.

KINDS OF HARDNESS PRESENT:

Hardness and Alkalinity relationship	Carbonate hardness	Non-Carbonate hardness
H is less than M	same amount as H	NONE
H = M	same amount as H	NONE
H is more than M	same amount as M	difference between H & M

Ca-H = Calcium hardness
Mg-H = Magnesium hardness
H = Total hardness
M = Total alkalinity

1. When H is 125 and M is 125 ______________________________________.
2. When M is 124 and H is 100 ______________________________________.
3. When H is 150 and M is 125 ______________________________________.
4. When Ca-H is 60, H is 90 and M is 90 ____________________________.
5. When M is 120, Ca-H is 50 and H is 150 __________________________.

Exercise II-6-e

PART I

Instructions: Complete the following statements.

1. Chlorides are found in water both __________ and as a result of __________________.
2. What causes chlorides to be present in ground water? _________________________.
3. More than _________ ppm chlorides will give water a salty taste.
4. More than _________ ppm chlorides can make you sick.
5. To test for chlorides we titrate the sample with ____________ ___________.

PART II

Instructions: List the following compounds in the correct columns in the table below.

a. $CaCl_2$
b. H_2SO_4
c. $NaCl$
d. $CaSO_4$
e. $MgSO_4$
f. $Ca(HCO_3)_2$
g. $MgCl_2$
h. $Mg(HCO_3)_2$
i. HCl

Compounds Causing Chlorides	Compounds Causing Sulfates

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

3770 Technical Training Group
Sheppard AFB, Texas

SW J3ABR56631 000-II-7

WASTEWATER ANALYSIS

OBJECTIVES

Given information, laboratory equipment and a wastewater sample, test the sample for Settleable Solids. No more than two instructor assists are allowed.

Given information, laboratory equipment and a sludge sample, perform Total Solids and Settleable Solids test. No more than two instructor assists are allowed for each test.

Given information, laboratory equipment and a wastewater sample, test the sample for Suspended Solids. No more than two instructor assists are allowed.

Given information, laboratory equipment and a wastewater sample, perform a Biochemical Oxygen Demand test. No more than two instructor assists are allowed.

Given information related to wastewater analysis and five facts concerning the purpose of Chemical Oxygen Demand (COD) testing method, match the facts with the information. Three of the five must be correct.

INTRODUCTION

The purpose of this study guide is to help you to understand and become familiar with the analyses which are required to gain the necessary information for proper operation of the waste disposal plant for the base.

The term "wastewater," as used in this study guide/workbook, refers to the spent water of a base or community containing the wastes from domestic and industrial uses. These wastes are collected in the sanitary sewer system and flows through the waste disposal plant, are treated and discharged into a receiving stream. On an average, wastewater is 99.9% (by weight) water. The remaining 0.1% contains the wastes produced in human habitations and consists of excrements, dirt from the laundry, dishwater and other household wastes, plus varying amounts of industrial wastes. It is frequently termed "sanitary sewage," a term indicating origin rather than condition.

The purpose of wastewater treatment is to remove the various solids and to reduce the dissolved organic matter and the biological oxygen demand to a level which will not deplete the dissolved oxygen in the receiving stream. It should be noted that a system without tertiary treatment does not remove the dissolved inorganic materials such as chlorides, sulfates, and phosphates from the water.

The purposes of the wastewater tests are to determine the degree of treatment required and to control the operation of a treatment plant to determine the efficiency and/or adequacy of the treatment, as shown by the quality of the effluent.

The characteristics of both treated and untreated wastewater may be determined by inspections or by tests to include: color, odor, B.O.D., pH, temperature, total solids, rate of settling, and strength of sewage.

Fresh sanitary sewage is normally gray in color, having the odor and appearance of dirty dishwater. Stale or "septic" sanitary sewage is dark to black in color with varying intensities of disagreeable odors. The change from fresh to septic sewage results from the action of bacteria present in the organic material which is contained in the sewage. The waste products in wastewater consist of both organic and inorganic materials. These impurities may be in the form of either suspended or dissolved solids. It is the organic matter which gives sewage its objectionable properties and it is the decomposition of this material by bacteria that results in the formation of septic sewage. The organic matter may be stable, meaning that it is resistant to bacterial breakdown or it may be unstable and breakdown easily.

The terms weak, medium, or strong are used to describe the strength of sewage. The concentration of waste materials in sewage will determine which term should be used. See Table 1 for conditions which have been designated as being either weak, medium, or strong.

Analysis	Weak	Medium	Strong
Total Solids	430	720	1200
Total Volatile Solids	240	420	810
Suspended Solids	100	200	370
Volatile Suspended Solids	70	130	220
Settleable Solids, mg/L.	2	4	6
Biochemical Oxygen Demand	100	210	410
Total Nitrogen	10	30	40
Ammonia Nitrogen	4	10	20
Soaps and Fats	6	10	20

Table 1. Average Composition of Various Strength Sewage at Military Installations, Expressed in mg/L (ppm).

BIOCHEMICAL OXYGEN DEMAND (B.O.D.)

The most important test that is normally performed on wastewater and the one giving the most information on the strength of the sewage is the B.O.D. test. As the name implies, it is the quantity of oxygen required for the biochemical oxidation in a given period of time and at a controlled temperature of 20°C for 5 days. The B.O.D. test utilizes oxygen from the air which has been dissolved in water. This condition simulates the conditions encountered in sewage purification which is why the test is so valuable.

In making the test a known volume of wastewater is mixed with a measured amount of water containing a predetermined amount of dissolved oxygen. The mixture is placed in a glass-stoppered bottle and kept at the proper temperature for the specified number of days. Under these conditions the sewage bacteria which are normally present will cause the organic matter to become oxidized. Dissolved oxygen will be used up in direct proportion to the amount of organic matter which is present. The decomposed products formed are mostly carbon dioxide (CO_2) and water (H_2O). At the end of the specified period of time the amount of dissolved oxygen remaining in the mixture is determined and the difference between the original and the final oxygen content can be calculated. The B.O.D. test is considered to be a direct measurement of the strength of the sewage. A B.O.D. of 95 ppm or less indicates weak sewage while a B.O.D. of 400 ppm or above indicates strong sewage.

SETTLEABLE SOLIDS

A test has been devised to accurately measure the amount of solids which will settle out. The tests may be made by using an Imhoff cone which is a piece of laboratory equipment named in honor of Dr. Karl Imhoff, the inventor of the Imhoff tank. This cone must be filled with well mixed wastewater to the one liter mark. The cone and its contents are allowed to stand for one hour after which the amount of settleable solids may be read directly in milliliters. The settleable solids may be expressed either as a quantity by weight or by volume--most frequently on a volume basis. By testing both the influent and effluent of a sedimentation tank, the percentage of solids removal and efficiency of tank may be found.

DETERMINATION OF THE SOLIDS CONTAINED IN WASTEWATER

Total Solids

Total solids include all of the dissolved solids plus all of the suspended solids contained in the wastewater. The total solids are normally expressed as mg/L. To determine the amount of total solids in a sample, it is necessary to evaporate the water content of a known volume of well mixed wastewater. To perform this test, take a previously weighed evaporating dish, add the measured sample of wastewater, and heat using a constant temperature between 103°C and 105°C. When the sample is dried, re-weigh the dish containg the dry residue and calculate the gain in weight. The gain in weight may be converted to mg/L.

Not all of the total solids are removed from wastewater by treatment received in the wastewater treatment plant. A large part of the soluable solids, which comprise the largest part of total solids, pass through the treatment devices unchanged. Soluable solids in wastewater will eventually dissolve.

One of the reasons for making the total solids test is to gain part of the information needed to calculate the dissolved solids content of wastewater.

Suspended Solids

Suspended solids are made up of settleable solids and non-settleable solids, which can be organic or inorganic matter. The suspended solids in wastewater are the solids which can be filtered out of a known volume of sample in a previously weighed Gooch crucible with a glass fiber filter pad, or other suitable filtering device. The sample should be well mixed prior to measuring out the correct volume for test purposes. The weight gain of the Gooch crucible indicates the amount of suspended solids present. It should be noted that suspended solids include the solids that would settle out of the wastewater after the carrying stream loses its velocity. Also, matter that is too light to settle, but which is trapped by the filter pad in a laboratory test is considered suspended solids. This test is useful in evaluating the efficiency of plant units. The overall removal in complete treatment is usually more than 90%.

Volatile Solids and Fixed Solids

It is desirable to determine how much of the total solids are made up of organic or "volatile" matter and how much is inorganic or "fixed" matter. The process of digestion can be measured by the destruction of organic matter (volatile solids). Reducing organic matter is measured by the volatile solids test which indicates the completeness of the digested matter. Raw sludge or primary settled sludge usually will contain 60 to 70 percent of volatile solids. Well digested sludge could have as little as 50 percent volatile solids. This well digested sludge should be black in color and not have an unpleasant odor. Volatilization may be accomplished by carefully igniting or burning the residue from the total solids test and noting the loss in weight which is called volatile matter. This test measures the amount of solids that vaporize at 550°C. Most organic compounds vaporize below 550°C, while most inorganic compounds must be heated in excess of 550°C before they will volatize. In practice the volatile matter is sometimes expressed in percentage by weight of the total amount of solids. The substance that is left in the evaporating dish after burning the organic matter is the inorganic matter or fixed solids. These fixed solids are composed of inert substances such as sand, metals, and minerals. The percent of fixed solids should not exceed 40-50 percent of the total solids content. The reason why the amount of organic matter must be known is because wastewater treatment is more concerned with organic matter while inorganic matter is of secondary importance. Organic matter contains the harmful, pathogenic diseases.

Tests on all of the above are performed using the gravimetric method of testing. The settleable solids and B.O.D. tests are considered in groups of their own even though they may contain steps similar to one or more of the four major methods.

Dissolved Solids

The amount of dissolved solids may be computed by subtracting the amount of suspended solids from the amount of total solids. This information is not normally required, however, it may be used to determine the character of raw wastewater or to show a high rate of industrial pollution. See Figure 7-1 for classification of solids in a typical sanitary sewage system.

SOLIDS

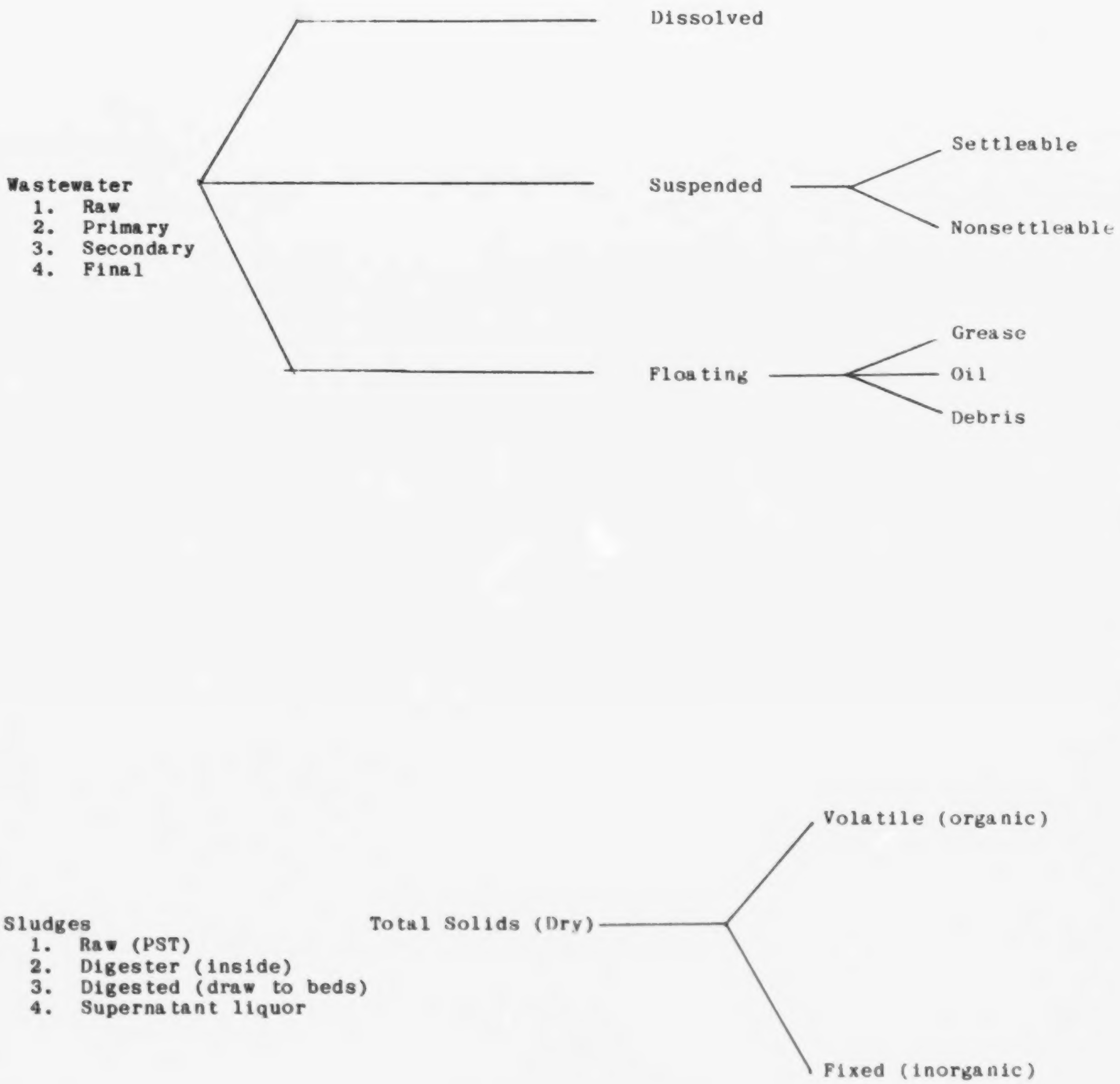

Dissolved
Settleable
Wastewater
1. Raw
2. Primary
3. Secondary
4. Final
Suspended
Nonsettleable
Grease
Floating
Oil
Debris
Volatile (organic)
Sludges
1. Raw (PST)
2. Digester (inside)
3. Digested (draw to beds)
4. Supernatant liquor
Total Solids (Dry)
Fixed (inorganic)

FIGURE 7-1. Total Solids Contained in a Typical Sanitary Sewage Sys

ADDITIONAL WASTEWATER TESTING

Volatile Acids

Volatile acids are found contained in the sludge of digestors. These organic acids are formed by anaerobic bacteria. Examples of organic acids are: acetic acid, better known as vinegar; citric acid, found in lemons; and formic acid. Formic acid is found in red ants. When volatile acids are present, an acidic environment exists which is unsuitable for digestion of organic matter. This condition is caused by pumping too much raw sludge into the digestor at one time, and/or by unthorough mixing. A test for volatile acids will determine the overall health of a digestor.

Grease - Grease is primarily composed of fatty matter from animals and oils from vegetables. Grease also contains soaps, waxes and other oils. By knowing the percentage of each minimizes the difficulty in determining the major source and simplifies the correction of grease problems in sewage treatment plants. Grease clogs pipes and filters, interferes with the settling rate, and prevents anaerobic bacteria from decomposing all organic matter properly.

A gravimetric test will determine the amount of grease in the digestor. Samples of oil film recovered from the surface of a stream or other body of water will be almost impossible to evaluate in relation to the total volume of water, total film area, and thickness involved.

Settling Rate - The settling rate test is primarily used at an activated sludge treatment plant. Many things effect the rate in which solids settle including the amount of grease, temperature, speed of flow through the primary settling tank, and the amount of aeration present.

C.O.D. - Of the organics in wastewater, a large part consists of biodegradable material - those which serve as a food source for bacteria. The amount of oxygen required to stabilize the biodegradable organics is measured by the BOD test. Some of the organics in wastewater, especially pesticides, are not biologically degradable and are not measured in the BOD test. The chemical oxygen demand (COD) is used to measure the amount of these materials present. Since more things can be oxidized chemically than biologically, the COD results will be higher than BOD. The COD has the advantage of being completed in about two hours instead of five days like the BOD test. This allows closer operational control of plant treatment processes. When a long term correlation between BOD and COD can be shown, then EPA may sometimes accept the COD test as a substitute for BOD test.

The test equipment that is required is a 300 mL round-bottom flask with a glass neck and a condenser. A hot plate, and a 500 mL Erlenmeyer flask, will be needed. The reagents required are sulfuric acid-silver sulfate solution, potassium dichromate solution, ferroin indicator solution, ferrous ammonium sulfate solution and mercuric sulfate crystals.

The generalized procedures used to perform the C.O.D. test are as follows:

1. Put 20-mL of sample in the flask; add 0.4 g of mercuric sulfate and 10 mL of potassium dichromate solution. Add 30 mL of sulfuric acid-silver sulfate solution and mix. Attach the flask to the condenser and heat the sample solution. Let cool.

2. Transfer the contents to a 500 mL Erlenmeyer flask; dilute the mixture to about 140 mL, cool and titrate the excess dichromate with ferrous ammonium sulfate solution, using the ferroin indicator -- usually 3 or 4 drops of indictor are added to the sample before titration.

Formula: $$\text{COD(mg/L)} = \frac{a - b \text{ X } c \text{ X } 8{,}000}{\text{mL of sample}}$$

COD - Oxygen used from potassium dichromate

a - mL ferrous ammonium sulfate solution used for the blank sample

b - mL ferrous ammonium sulfate solution for the sample

c - normality of ferrous ammonium sulfate solution

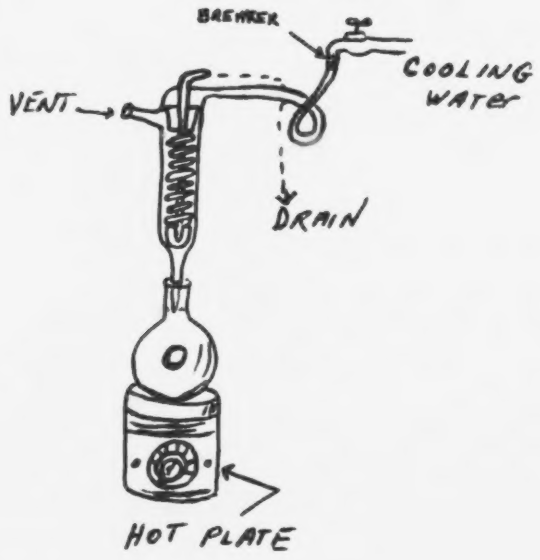


FIGURE 7-2. Apparatus Used for C.O.D.

Nitrogen compounds - Nitrogen compounds are important in the control of wastewater treatment plants. There are four types of nitrogen compounds which you should become familiar with. They are: organic -N, ammonia -N, nitrate -N, and total nitrogen. Total -N is made up of organic and ammonia nitrogen.

Nitrate nitrogen is probably the most important since its presence tells us the stabilization process is complete. A rise in organic nitrogen content may often be related to the sewage or industrial waste pollution of a given water supply.

Sulfide Compounds - Hydrogen sulfide (H_2S) is released by anaerobic decomposition, indicating there is no oxygen present in the wastewater. This often means you have a septic condition. Hydrogen sulfide in solution lends a disagreeable taste and rotten-egg odor to water. Concentrations of a few tenths of a milligram per liter cause an objectionable smell, while higher concentrations or low concentrations over an extended period of time are deadly. Never leave sludge in the digestor long enough to form this gas.

Ground water absorbs sulfides by passing over sulfur-bearing rocks. Hydrogen sulfide when in water or exposed to oxygen can turn into sulfuric acid which attacks concrete and cement in sewers causing "crown" corrosion. Samples must be taken with a minimum amount of aeration to prevent oxygen from chemically combining and thus changing the hydrogen sulfide content.

TESTING FOR COLIFORM BACTERIA

To insure there has been no pollution of potable water supplies, every week tests must be performed to detect any presence of coliform bacteria. For the routine examination of most potable water supplies, the object of the test is to determine the presence or absence of coliform organisms. Also it measures the efficiency of plant operation. At least 95% of all samples examined should give negative results. One positive result does not mean the water is contaminated. But three out of five or more positive results is good reason for some type of action. Any observable increase in the number of positive samples also is a good indication of trouble in your treatment process.

The coliform bacteria originate in the intestines of man and other warm blooded animals. They themselves are not harmful, but show us that other harmful bacteria (for which there is no easy test), could be living in the water (Pathogens). The fecal coliform test is an indicator of harmful bacteria in the wastewater. Both the multiple-tube fermentation test which is expressed as "Most Probable Number" (MPN) and the millipore membrane filter test or Membrane Filter (MF) are used to check for coliform in water and wastewater. The coliform group density is expressed as the degree of pollution. The test and test results are used as a basis for the standards of bacteriological quality of water supplies. Extreme care must be taken to provide sterile sample bottles and testing equipment so not to alter the actual bacteria count.

The MPN multiple-tube fermentation method is based on the appearance of gas bubbles in small vials or tubes produced by the fermentation of a lactose broth medium. This incubation time could range from 24 to 96 hours. The MF or millipore membrane filter test is used to collect coliform from larger more representative samples of water. When the sample is passed through the filter, microorganisms that are larger than the filter pores are trapped on the filter surface where they can be cultured to form visible colonies. The various coliform colonies will develop different colors providing a direct count of coliform within 24 hours.

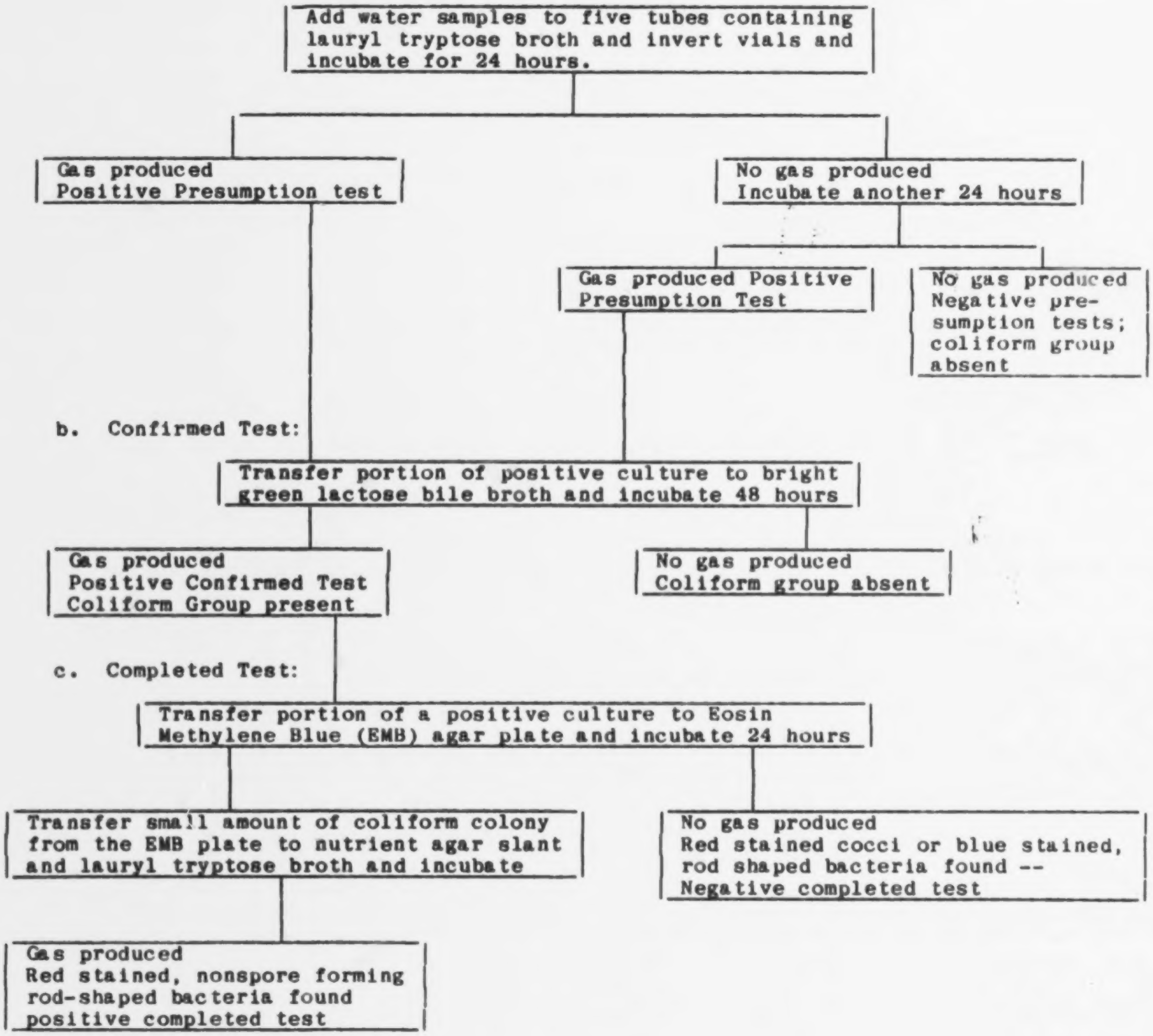
Test results are usually reported by the multiple-tube fermentation procedure as a Most Probable Number (MPN) index. This index is a number of coliform bacteria which merely give the results shown by laboratory testing. It is not on actual count of bacteria. The direct plating method such as the membrane filter procedure will give a direct count of bacteria or coliform colonies. In both of the methods above, coliform density is reported as the membrane filter count (MPN) per 100 mL. Both procedures are good for checking the sanitary quality of water and the effectiveness of the treatment plant process.

When testing for coliform using the test tubes procedure, four types of test tubes can be used to check for active formations produced by the bacteria: a presumptive test with a dehydrated lactose broth contained in the test tube; a lauryl tryptose broth used to detect bacteria which causes gas formations in the tube; a confirmed test that contains a bright green lactose bile broth which identifies total coliform bacteria; and an E.C. medium test that when the sample is incubated at tempertures higher than the gas formation, temperatures of the nonfecal coliform will then indicate the presence of fecal coliform bacteria. The multiple tube dilution procedure requires separate tubes for each amount of sample to be tested and a minimum of three dilutions of each sample. If there are five samples with three dilutions of each sample, you will have fifteen fermentation test tubes to anlayze. This procedure must be performed with extreme care and accuracy. Many steps are involved in taking each sample, preparing the various dilutions and incubating the samples at specific temperatures for a set time that begins at a 24 hour period and could take as long as 48 or 96 hours. Remember, the fermentation tube test will give you positive results but will not indicate the numerical count of bacteriological colonies.

The membrane filter (MF) technique is used for analyzing water throughout the interstate water ways. This test can reproduce bacteria very well when testing large volumes of water samples. This test is able to yield a positive result in the sample faster than the standard tube tests. Results are made in 24 hours and more representative samples of water can be made more routinely. The numerical counts from membrane filters have better accuracy than with the fermentation tube method and the equipment and supplies are less bulky. Also, more individual total samples can be made with less space used up in the laboratory.

Total and fecal coliform tests are by far one of the most important tests taken for water quality standards. Information explaining detailed methods and procedures pertaining to coliform tests can be found in Standard Methods for the Examination of Water and Wastewater and other microbiological-millipore publications.

a. Presumptive Test:



Add water samples to five tubes containing lauryl tryptose broth and invert vials and incubate for 24 hours.

Gas produced
Positive Presumption test

No gas produced
Incubate another 24 hours

Gas produced Positive Presumption Test

No gas produced
Negative presumption tests; coliform group absent

b. Confirmed Test:

Transfer portion of positive culture to bright green lactose bile broth and incubate 48 hours

Gas produced
Positive Confirmed Test
Coliform Group present

No gas produced
Coliform group absent

c. Completed Test:

Transfer portion of a positive culture to Eosin Methylene Blue (EMB) agar plate and incubate 24 hours

Transfer small amount of coliform colony from the EMB plate to nutrient agar slant and lauryl tryptose broth and incubate

No gas produced
Red stained cocci or blue stained, rod shaped bacteria found -- Negative completed test

Gas produced
Red stained, nonspore forming rod-shaped bacteria found positive completed test

FIGURE 7-3. Multiple-tube Termentation Method of Process Control

SUMMARY

There are a few additional tests which you may or may not perform in the field. Some deal with wastewater, others with water. In this last chapter we have talked about a few wastewater and one water test. A basic understanding of each is required.

Volatile acids are organic acids found in the sludge of digestors. The smallest amount of them as possible is desired because their presence is unsuitable for the digestion of organic matter. A test for volatile acids will determine the overall health of a digestor.

Grease is composed of animal fats, oils, soaps and waxes. They clog pipes and filters, interfere with settling rates, and prevent anaerobic bacteria from decomposing organic matter properly. A gravimetric test will determine the amount of grease in the digestor.

Hydrogen sulfide (H_2S) is released by anaerobic decomposition which indicates that there is no oxygen present. This often means you have a septic condition. The gas has a rotten-egg odor which varies in concentrations depending on the septic conditions. Never leave sludge in the digestor long enough to form this gas. When combined with oxygen, H_2S becomes a highly corrosive sulfuric acid.

Nitrogen compounds come in four basic types; organic, ammonia, nitrate, and total. Nitrate nitrogen if present indicates the stabilization process is complete. A rise in organic nitrogen content may often be related to the sewage or industrial waste pollution of a given water supply.

C.O.D. is a test performed in the place of B.O.D. It takes two hours to complete and its results are comparable to that of the B.O.D. C.O.D. does require certain equipment and has not been recognized by the EPA. C.O.D. is especially good to test where there is industrial waste.

Settling rate is effected by many things including the amount of grease, temperature, speed of flow through the primary settling tank and the amount of aeration present.

Coliform bacteria is tested to insure harmful bacteria are not present. Coliform originate in the intestines of man and other warm blooded animals. Extreme care must be taken to provide sterile sample bottles.

Exercise II-7-b

Instructions: Complete the following questions.

1. What does D.O. and B.O.D. represent.

2. List the three major chemicals used to prepare a D.O. and a B.O.D.
    a.
    b.
    c.

3. What reagent is used to titrate either a D.O. or B.O.D.?

4. What is the purpose for preparing and testing a "blank" dilution water sample?

5. At what temperature are the B.O.D. samples incubated?

6. Tell what a BOD_5 measures in a wastewater sample.

7. List five laboratory equipment or glassware used with the performance of a D.O. or B.O.D. test.
    a.
    b.
    c.
    d.
    e.

Exercise II-7-c

Instructions: Complete the following questions:

1. How does grease interfere with settling rates?

2. What factors influence the settling rate?

3. How many milliliters of sample are required to run a settleable solids test?

4. What is the total time required to run a settleable solids test?

5. What three types of wastewater effluent samples are measured when performing a settleable solids test?

   a.

   b.

   c.

6. What laboratory devices are used to perform a settleable solids test?

Exercise II-7-d

Instructions: Complete the following questions.

1. List three types of solids which are catagorized under total solids.

   a.

   b.

   c.

2. What type of sample is usually used to test for total solids?

3. What are three pieces of equipment used to evaporate the water content of a sample for the total solids test?

   a.

   b.

   c.

4. What unit is used to dry the total solids sample?

5. What unit is used to burn or volatilize the total solids sample?

6. What unit is used to cool a solids sample without absorbing moisture into the sample?

7. What piece of equipment is used to weigh the solids samples?

8. What substance is classified as volatile matter?

9. What substance is classified as fixed matter?

10. List at least three safety items or equipment used during the performance of the total solids test.
    a.
    b.
    c.

Exercise II-7-e

Instructions: Complete the following questions.

1. What piece of equipment is used to filter out the suspended solids in a wastewater sample?

2. How are the suspened solids drawn through the filter element?

3. What three types of wastewater samples are usually filtered when performing a suspended solids test?
    a.
    b.
    c.

4. What device is used to dry a suspended solids sample?

5. How long is required to completely dry a suspended solids sample?

6. What unit is used to cool a suspended solids sample without letting moisture absorb into the sample?

7. What device is used to weigh the suspended solids sample?

Execise II-7-f

Instructions: Complete the following questions.

1. Why is coliform bacteria harmful?

2. What type of bottle(s) is/are used collecting a sample to test for coliform bacteria?

3. List at least two diseases caused by pathogenic bacteria.
   a.
   b.

4. Why are coliform bacteria not considered pathogenic or disease producing?

5. What precautions must be followed to produce correct bacteriological test results?

6. Why must sample bottles be sterilized before a bacteriological test is performed?

Expercise II-7-g

Instructions: Complete the following questions.

1. What do the letters "C.O.D." represent?

2. List three advantages of performing the C.O.D. compared to the BOD_5.
   a.
   b.
   c.

3. List three chemicals used in the performance of a C.O.D. test.
   a.
   b.
   c.

4. List two pieces of lab equipment used to perform a C.O.D. test.
   a.
   b.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

PROGRESS CHECK
J3ABR56631 000-II-1 Thru 7

Technical Training

Environmental Support Specialist

WATER AND WASTEWATER ANALYSIS

June 1986

3700 Technical Training Wing
3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

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Supersedes WB 3ABR56631 000-II-1 thru 7, June 1984

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-1a
June 1986

RELATED MATHEMATICS

OBJECTIVE:

Solve problems in addition, subtraction, multiplication, and division of whole numbers.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 4 items. You must solve each item correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions start your progress check.

DIRECTIONS:

1. Solve each of the following problems correctly.

(1) $\begin{array}{r} 9479 \\ 6364 \\ 2469 \\ \underline{+\ 9785} \end{array}$

(2) $\begin{array}{r} 5302 \\ \underline{-\ 2807} \end{array}$

(3) $\begin{array}{r} 1801 \\ \underline{\times\ 191} \end{array}$

(4) $43\ /\ \overline{126764}$

-- STOP --

Instructor's Initials

RELATED MATHEMATICS

OBJECTIVE:

Solve problems in addition, subtraction, multiplication, and division of decimals.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 4 items. You must solve each item correctly to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

Solve each of the following problems correctly.

1. 2.18 + 34.35 + .14 + 4.9 + 1.0 = ____________________

2. 45.561 - 31.2432 = ____________________

3. $\begin{array}{r} .059 \\ \underline{\times\ 83.2} \end{array}$

4. .02958 ÷ .12 = ____________________

-- STOP --

Before proceeding any further have the instructor check your answers.

Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-1c

RELATED MATHEMATICS

OBJECTIVE:

Solve problems in addition, subtraction, multiplication, and division of fractions.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 4 items. You must solve each item correctly to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

Solve each of the following problems correctly.

1. 5/6 + 2/9 = ______________________

2. 2 7/8 - 1 1/8 = ______________________

3. 4/5 x 3/5 = ______________________

4. 9 ÷ 2/7 = ______________________

-- STOP --

Before proceeding any further have the instructor check your answers.

Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-1d
June 1986

RELATED MATHEMATICS

OBJECTIVE:

Given the formulas, dimensions, and a geometric figure of a square, rectangle, and circle, compute the area of each.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 3 items. You must solve each item correctly to receive a satisfactory rating.

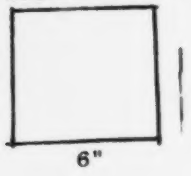
2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

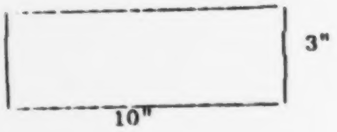
Solve each of the following problems correctly.

1.



Area = S2 A = ____________

2.



Area = L x W A = ______________

3. D= 40" Area = x R2 A = ______________

-- STOP --

Before proceeding any further have the instructor check your answers.

Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-1e
June 1986

RELATED MATHEMATICS

OBJECTIVE:

Given the formulas, dimensions, and a geometric figure of a square, rectangle, and circle, compute the volume of each.

REFERENCE/MATERIAL/EQUIPMENT:

None

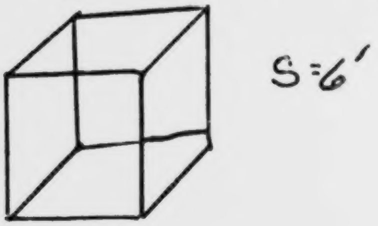
INSTRUCTIONS:

1. This progress check consists of 3 items. You must solve each item correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

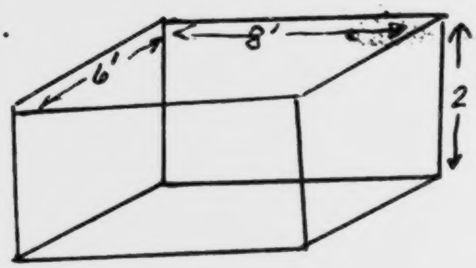
DIRECTIONS:

Solve each of the following problems correctly.

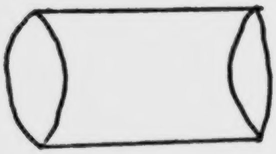
1. Volume = S3 V = ______________



2. Volume = L x W X H V = ________________



3. Volume =   x r2 x H V = ______________



-- STOP --

Before proceeding any further have the instructor check your answers.

Instructor's Initials

RELATED MATHEMATICS

OBJECTIVE:

Given problems pertaining to a typical water supply system and a maximum of three instructor assists, follow the correct procedure to complete each problem.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 6 items. You must solve each item correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. You are authorized a maximum of three instructor assists.
4. If you have no questions, start your progress check.

DIRECTIONS:

Solve each of the following problems correctly. Round off all answers to a whole number.

1. a. A swimming pool measures 64 ft. by 43 ft., and is 2 ft. deep at one end and 12 ft. deep at the other end. How large is the pool?

____

b. How many gallons of water will this pool hold?

c. If a pump delivers 40 gallons per minute, how long will it take to fill this pool? ________ Hrs. ____________ Min.

2. a. A water storage tank 56 ft. in height, with a diameter of 28 ft. contains how many gallons of water when full? ______________________

b. Assuming this tank is full, what would the psi be at the bottom of the tank.

____

3. You are told to disinfect a tank of water which holds 750,000 gallons when full. In stock there is some dry powder chlorine that is 70% pure. How many pounds of chlorine will you need to reach a 5.0 ppm content of chemical?

____

-- STOP --

Before proceeding any further have the instructor check your answers.

Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-1g
June 1986

RELATED MATHEMATICS

OBJECTIVE:

Given the temperature conversion formulas, convert temperature between the metric and English systems.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 2 items. You must solve each item correctly to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

1. Solve each of the following problems correctly.

Instructions: Change the following C° temperatures to F° and F° to C°.

1. $C = 5/9 \times (F-32)$

   68°F = ________°C

2. $F = 9/5 \times C + 32$

   10°C = ________°F

-- STOP --

Before proceeding any further have the instructor check your answers.

Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-2a
June 1986

PRINCIPLES OF PHYSICS

OBJECTIVE:

Given information and a list of eight incomplete statements concerning physics, complete the statements. Five of the eight must be correct.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 8 items. You must solve 5 item correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS:

Complete each statement so that it will state a correct fact about physics.

Exercise 2a

Instructions: Complete each statement so that it will state a correct fact about physics.

1. Physics is the study of __________ and ______________________________.
2. Energy is ____.
3. Kenetic and Potential are two types of ______________________________.
4. Define matter ____.
5. List the three states of matter.
   a. ____
   b. ____
   c. ____
6. What are two factors that cause a change of matter from one physical state to another?
   a. ____
   b. ____
7. Any material or substance that can be reduced to a simpler form is known as a ____.
8. If you were trying to find the density of a substance, you would divide the weight by the ____.

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-3a
June 1986

PRINCIPLES OF CHEMISTRY

OBJECTIVE:

Given a list of twenty chemical terms, elements, radicals, and other related terms, match them with their definitions and/or symbols. Sixteen of the twenty terms must be correct.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 20 items. You must solve 16 items correctly to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

1. Solve each of the following problems correctly.

COLUMN I

1. ( ) The process by which molecules break up to form ions
2. ( ) The weight of a unit volume of matter
3. ( ) A number which shows the comparative weight of one atom
4. ( ) A number which shows the number of protons contained in one atom
5. ( ) The relative combining capacity of an element
6. ( ) The weight of an element which will react chemically with another element
7. ( ) A substance composed of two or more elements, chemically combined
8. ( ) An ion composed of two or more elements combined chemically
9. ( ) Sub-atomic particle with a (+) charge
10. ( ) Atom or radical with an electrical charge
11. ( ) Sub-atomic particle with a (-) charge
12. ( ) Ion with a (+) charge

COLUMN II

a. Atomic number
b. Concentrated solution
c. Formula
d. Anion
e. Proton
f. Molecular weight
g. Ionization
h. Valence
i. Solvent
j. Molecule
k. Atomic weight
l. Equivalent weight
m. Radical
n. Density
o. Ion
p. Electron

-- STOP --

Before proceeding any further have the instructor check your answers.

_______________ Instructor's Initials

13. ( ) Weight of one molecule of a compound

14. ( ) Smallest part of a compound

15. ( ) Abbreviation for the name of a compound

16. ( ) An ion with a (-) charge

17. ( ) A solution containing a large amount of solute per unit volume

18. ( ) A substance which has been dissolved

19. ( ) A substance which will dissolve another substance

20. ( ) A uniform mixture of two or more substances in liquid form

q. Cation

r. Solute

s. Compound

t. Solution

-- STOP --

Before proceeding any further have the instructor check your answers.

_______________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-3b
June 1986

PRINCIPLES OF CHEMISTRY

OBJECTIVE:

Given a list of 25 chemical compounds and their formulas, match the chemical compounds with their formulas and indicate whether the compound is an acid, base, or salt. At least 12 of 15 must be correct.

REFERENCE/MATERIAL/EQUIPMENT:

SW J3ABR56631 000-II-1 thru 7

INSTRUCTIONS:

1. This progress check consists of 15 items. You must solve 12 items correctly to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

Instructions: Place the letter of the matching formula in the space provided preceding the correct compound in Column I, also indicate in the space provided following the compound if it is an acid, base, or salt by placing an "a" for acid, a "b" for base or an "s" for salt in that space.

COLUMN I	COLUMN II
1. ( ) Calcium carbonate ( )	a. $Mg(SO_4)$
2. ( ) Hydrochloric acid ( )	b. $Na(OH)$
3. ( ) Sulfuric acid ( )	c. $Ca(CO_3)$
4. ( ) Sodium Hydroxide ( )	d. $H_2(SO_4)$
5. ( ) Magnesium Hydroxide ( )	e. $H(NO_3)$
6. ( ) Potassium hydroxide ( )	f. $Ca(SO_4)$
7. ( ) Nitric acid ( )	g. $K(OH)$
8. ( ) Calcium hydroxide ( )	h. $Ca(OH)_2$
9. ( ) Sodium chloride ( )	i. H_2SiO_3
10. ( ) Carbonic acid ( )	j. $Mg(OH)_2$
11. ( ) Calcium bicarbonate ( )	k. Fe_2O_3
12. ( ) Calcium sulfate ( )	l. $H_2(CO_3)$
13. ( ) Ferric oxide ( )	m. $NaCl$
14. ( ) Silicic acid ( )	n. $Ca(HCO_3)_2$
15. ( ) Magnesium sulfate ( )	o. HCl

-- STOP --

Before proceeding any further have the instructor check your answers.

_________________ Instructor's Initials

PRINCIPLES OF CHEMISTRY

OBJECTIVE:

Given a list of ten compounds write formulas describing each compound. Seven of the 10 formulas must be correct.

REFERENCE/MATERIAL/EQUIPMENT:

SW J3ABR56631 000-II-1 thru 7

INSTRUCTIONS:

1. This progress check consists of 10 items. You must solve 7 items correctly to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

Using a list of common ions, write the formulas for the following components. Be sure to include symbols, subscripts, and valences.

1. Sodium Bicarbonate ____________________
2. Calcium phosphate ____________________
3. Magnesium hydroxide ____________________
4. Hydrogen chloride ____________________
5. Hydrogen phosphate ____________________
6. Potassium sulfite ____________________
7. Aluminum phosphate ____________________
8. Calcium oxide ____________________
9. Ferric chloride ____________________
10. Ferric sulfate ____________________

-- STOP --

Before proceeding any further have the instructor check your answers.

____________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-3d
June 1986

PRINCIPLES OF CHEMISTRY

OBJECTIVE:

Given five sets of reactants, write balanced chemical equations. Three of the five must be correct.

REFERENCE/MATERIAL/EQUIPMENT:

SW J3ABR56631 000-II-1 thru 7

INSTRUCTIONS:

1. This progress check consists of 5 items. You must solve 3 items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS:

Using a list of common ions, balance the following double-displacement equations. Be sure to include all symbols, subscripts, co-efficients and valences.

1. Calcium hydroxide + sulfuric acid -->

________________ + ________________ --> ________________ + ________________

2. Sodium sulfate + zinc nitrate -->

________________ + ________________ --> ________________ + ________________

3. Aluminum sulfate + Calcium hydroxide -->

________________ + ________________ --> ________________ + ________________

4. Barium hydroxide + sulfuric acid -->

________________ + ________________ --> ________________ + ________________

5. Copper sulfate + sodium chloride -->

________________ + ________________ --> ________________ + ________________

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

LABORATORY SAFETY

OBJECTIVE:

Given information pertaining to laboratory chemicals, identify the statements pertaining to their use and care as true or false. Three of five answers must be correct.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 5 items. You must get 3 items correct to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

Mark the following statements either true (T) or false (F).

____1. You should always add acid to water instead of water to acid.

____2. It is ok to use chemicals in the lab, that are not labeled, if you know what they are.

____3. If a chemical is spilled on your arm, you should immediately wash it off.

____4. Never mix chemicals at random.

____5. Sometimes you may need to taste a chemical to help identify it.

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-4b
June 1986

LABORATORY SAFETY

OBJECTIVE:

Given a list of 10 statements pertaining to the use and care of laboratory equipment, match the identifying statements to the correct piece of equipment. Seven of the ten answers must be correct.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 10 items. You must solve 7 items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS:

Place the letter indicating the correct term in the space preceding the statement in Column I.

COLUMN I

1. ( ) Used to transfer exact quantities of liquid reagents.
2. ( ) Used to evaporate water samples under controlled conditions.
3. ( ) Used to volatize organic matter.
4. ( ) May be used as a container when heating samples over a burner.
5. ( ) Used to heat samples.
6. ( ) Used to measurae temperature.
7. ( ) Used to weigh samples during gravimetric analysis.
8. ( ) Container in which "solids" samples are placed to cool.
9. ( ) Used to measure exact volume of dry powder.
10. ( ) Container for sample which is swirled during titration.

COLUMN II

a. Bunsen burner
b. Pipette
c. Dessicator
d. Erlenmeyer flask
e. Steam bath
f. Evaporating dish
g. Analytical balance
h. Thermometer
i. Chemical dipper
j. Muffle furnace

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-5a
June 1986

COLLECT WATER AND WASTEWATER SAMPLES

OBJECTIVE:

Given information, the appropriate sampling device, and a maximum of one instructor assist, collect and label a water sample to test for various impurities.

REFERENCE/MATERIAL/EQUIPMENT:

Lab station	Rubber Hose
Misc. Glassware	3" x 5" Index Card

INSTRUCTIONS:

1. This progress check consists of two performance items. You must perform both items correctly to receive a satisfactory rating.

2. You are authorized a maximum of one instructor assist.

3. Your instructor will monitor your performance on item 1.

4. When you have completed this progress check, report to your instructor.

5. If you have no questions, start your progress check.

DIRECTIONS:

Using the following checklist, collect and label a water sample from a given source, which could be used to test for dissolved gases. The sample will be taken from an area designated by the instructor.

1. Collect the sample
   a. Obtain a clean water sample bottle from the lab.
   b. Go to the sampling point designated by the instructor.
   c. Open the tap and allow water to flow long enough to draw water from the main before you collect the sample.
   d. Rinse the sample container with water from the tap.
   e. Attach a rubber hose to the tap and let water flow until all air is removed from the hose.
   f. Place end of hose near the bottom of sample bottle and using a slow, steady flow, fill sample bottle to overflowing.
   g. Turn off tap and immediately cap sample bottle.
2. Label sample giving the following information.
   a. Name of collector.
   b. Date sample collected
   c. Temperature of sample.
   d. Place sample was taken at.
   e. Type of analysis needed.

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-5b
June 1986

COLLECT WATER AND WASTEWATER SAMPLES

OBJECTIVE:

Using given information and a maximum of one instructor assist, list the procedures for collecting a sample of wastewater and a sample of sludge.

REFERENCE/MATERIAL/EQUIPMENT:

AFM 91-32

INSTRUCTIONS:

1. This progress check consists of 3 items. You must solve each item correctly to receive a satisfactory rating.

2. You are authorized a maximum of one instructor assist.

3. When you have completed the progress check, return it to your instructor.

4. If you have no questions, start your progress check.

DIRECTIONS:

Using paragraph 16.1.6 and table 16-1 in AFM 91-32, correctly list the procedures used to collect and label a wastewater sample.

1. Collect the sample.

   a.

   b.

   c.

   d.

   e.

   f.

2. Label the sample.

   a.

   b.

   c.

   d.

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

e.

Instructions: Using information from your study guide, list the procedures used to collect a sludge sample from an anaerobic digestor.

1.

2.

3.

4.

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

WATER ANALYSIS

OBJECTIVE

Using appropriate laboratory equipment and testing procedures test various samples of water for pH, temperature and specific conductance. No more than one instructor assist is allowed for each test.

REFERENCE/MATERIAL/EQUIPMENT:

pH meter
Thermometer
pH buffer
Lab manual
Specific Conductance Meter
Misc. Glassware
Water Samples
Lab Station

INSTRUCTIONS:

1. This progress check consists of 3 laboratory tests. You must perform each test correctly to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

Test various samples of water for pH, temperature, and specific conductance. Use the information given below and record your answers. Be sure to follow all safety precautions.

1. pH

To run a pH test follow the instructions on pages 17-19 in your lab manual.

pH of sample = ______________________

2. TEMPERATURE

To test for temperature follow the instructions on page 31 of your lab manual.

Temperature of sample = ______________________________

3. SPECIFIC CONDUCTANCE

To test for specific conductance follow the instructions on page 28 in the lab manual.

Specific conductance of sample = ______________________________

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-6b
June 1986

WATER ANALYSIS

OBJECTIVE:

Given information, laboratory equipment, and various water samples, test the samples for chlorine residual, turbidity, iron, and fluorides. No more than one instructor assist is allowed for each test.

REFERENCE/MATERIAL/EQUIPMENT:

Hach DR-3000 Spectrophotometer
Hach DR-3000 Spectrophotometer Instrument Manual
Lab Manual
Lab Station
Water Station
Hach Turbidity Meter
Water Samples
Misc Reagents
Misc Glassware

INSTRUCTIONS:

1. This progress check consists of 4 laboratory tests. You must perform each test correctly to receive a satisfactory rating.

2. You are allowed one instructor assist.

3. When you have completed the progress check, return it to your instructor.

4. If you have no questions, start your progress check.

DIRECTIONS:

Test various samples of water for chlorine residual, turbidity, iron, and flouride. Use the information given below and record your answers. Be sure to follow all safety precautions.

1. CHLORINE RESIDUAL

To run a chlorine residual test folow the instructions in Part 3, Test Procedures of HACH DR/3000 Spectrophotometer Instrument Manual.

Chlorine residual = __________ ppm

2. IRON

To test for iron follow the instructions in Part 3, Test Procedures of HACH DR/3000 Spectrophotometer Instrument Manual.

Iron = __________ ppm

3. FLOURIDE

To test for flouride follow the instructions in Part 3, Test Procedures of HACH DR/3000 Spectrophotometer Instrument Manual.

Flouride = ______________ ppm

4. TURBIDITY

To test the turbidity of a sample, follow the directions in your lab manual pages 34 and 35 for a Hach Turbidity Meter Model 2100A.

Turbidity = ___________________ NTU

-- STOP --

Before proceeding any further have the instructor check your answers.

_________________ Instructor's Initials

WATER ANALYSIS

OBJECTIVE:

Given laboratory equipment, HACH DR-3000 spectrophotometer methods manual and a water sample, test the sample for true color, with no more than one instructor assist.

REFERENCE/MATERIAL/EQUIPMENT:

HACH DR-3000 Spectrophotometer
HACH DR-3000 Spectorphotometer Instrument Manual
Water Samples

Misc. Glassware
Lab station

INSTRUCTIONS:

1. This progress check consists of 1 laboratory test item. You must perform test item correctly to receive a satisfactory rating.

2. You are allowed one instructor assist.

3. When you have completed the progress check, return it to your instructor.

4. If you have no questions, start your progress check.

DIRECTIONS:

Test a water sample for color using the information in the DR/3000 Spectrophotometer Manual. Disregard the instructions for filtering the sample in steps #3 and 4 of the procedure. Record your answer below.

Color = ____________ color units

-- STOP --

Before proceeding any further have the instructor check your answers.

______________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-6d
June 1986

WATER ANALYSIS

OBJECTIVE:

Given information, laboratory equipment, and various water samples, test the samples for hardness, acidity and alkalinity. No more than two instructor assists are allowed.

REFERENCE/MATERIAL/EQUIPMENT:

Lab Station
Misc Glassware
Water samples
Misc Reagents
Lab Manual

INSTRUCTIONS:

1. This progress check consists of 3 laboratory tests. You must perform them correctly to receive a satisfactory rating.

2. You are authorized two instructor assists for each test.

3. When you have completed the progress check, return it to your instructor.

4. If you have no questions, start your progress check.

DIRECTIONS:

Test various samples of water for hardness, alkalinity, and acidity. Use the information given below and record your answers. Be sure to follow all safety precautions.

1. HARDNESS

To run a hardness test follow the instructions on pages 13 and 14 of your lab manual.

Total Hardness = ____________ ppm

Ca Hardness = ____________ ppm

Mg Hardness = ____________ ppm

2. ACIDITY

To run an acidity test follow the instructions on pages 1 and 2 of your lab manual.

FMA = ____________ mg/L

Total Acidity = ____________ mg/L

3. ALKALINITY

To run an alkalinity test follow the instructions on pages 3 thru 5 in your lab manual.

P Alkalinity = ____________ mg/L

M Alkalinity = ____________ mg/L

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-6e
June 1986

WATER ANALYSIS

OBJECTIVE:

Given the types of phosphate compounds and a list of statements pertaining to phosphates, match each type of compound to the statements. Three out of five statements must be correct.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 5 items. You must solve each item correctly to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

Match the correct answer in Column I to the statement in Column II. Each answer may be used once, more than once, or not at all.

COLUMN I

a. Ortho - phosphates

b. Poly - phosphates

COLUMN II

1. _____ Used to stabilize water.

2. _____ Must be boiled because they can not be measured directly.

3. _____ May be used to soften water.

4. _____ Can be measured using the clorimeter method.

5. _____ Are considered contaminates in wastewater because they cause aging in receiving waters.

-- STOP --

Before proceeding any further have the instructor check your answers.

_________________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-6f
June 1986

WATER ANALYSIS

OBJECTIVE:

Given five incomplete statements concerning chloride compounds, complete the statements as they pertain to the compound type, source and testing procedures. Three of the five completed statements must be correct.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 5 items. You must solve 3 items correctly to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

Complete each statement so that it will state a correct fact about chlorides.

1. EPA recommends that if chlorides exceed __________ ppm they should be removed.
2. Excessive amounts of chlorides will cause the water to taste ________________.
3. We use the _____________________ method of testing to to test for chlorides.
4. A sudden increase of chlorides in drinking water may indicate __________ __________.
5. The most common forms of chlorides in drinking water are __________, __________, and ____________.

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-7a
June 1986

WASTEWATER ANALYSIS

OBJECTIVE:

Given information, laboratory equipment, and a wastewater sample, test the sample for Settleable Solids. No more than two instructor assists are allowed.

REFERENCE/MATERIAL/EQUIPMENT:

Wastewater Samples
Imhoff Cone
Lab Manual
Lab Station

INSTRUCTIONS:

1. This progress check consists of a laboratory test. You must perform this test correctly to receive a satisfactory rating.

2. You are authorized two instructor assists.

3. When you have completed the progress check, return it to your instructor.

4. If you have no questions, start your progress check.

DIRECTIONS:

Follow the directions on page 22 in your lab manual and test a wastewater sample for settleable solids.

_________________ mL/L settleable solids

-- STOP --

Before proceeding any further have the instructor check your answers.

_________________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-II-7b
June 1986

WASTEWATER ANALYSIS

OBJECTIVE:

Given information, laboratory equipment, and a sludge sample, perform Total Solids and volatile Solids test. No more than two instructor assists are allowed for each test.

REFERENCE/MATERIAL/EQUIPMENT:

Wastewater Samples
Lab Station
Analytical Balance
Drying Oven
Muffle Furnace
Dessicator
Misc Glassware
Lab Manual

INSTRUCTIONS:

1. This progress check consists of 3 laboratory tests. You must perform each test correctly to receive a satisfactory rating.

2. You are allowed two instructor assists for each test.

3. When you have completed the progress check, return it to your instructor.

4. If you have no questions, start your progress check.

DIRECTIONS:

Follow the directions on pages 25, 26, and 27 in your lab manual and test a sludge sample for total, fixed, and volatile solids.

__________ mg/L total solids

__________ mg/L fixed solids

__________ mg/L volatile solids

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

WASTEWATER ANALYSIS

OBJECTIVE:

Given information, laboratory equipment, and a wastewater sample, test the sample for Suspended Solids. No more than two instructor assists are allowed.

REFERENCE/MATERIAL/EQUIPMENT:

Wastewater Samples
Misc Glassware
Lab Station
Analytical Balance
Lab Manual
Vacuum Flask
Vacuum Pump

INSTRUCTIONS:

1. This progress check consists of one laboratory test. You must correctly perform this test to receive a satisfactory rating.

2. You are allowed two instructor assists.

3. When you have completed the progress check, return it to your instructor.

4. If you have no questions, start your progress check.

DIRECTIONS:

Follow the directions on pages 23 and 24 in your lab manual and test a wastewater sample for suspended solids.

________________ mg/L suspended solids

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

WASTEWATER ANALYSIS

OBJECTIVE:

Complete four statements concerning the test for Coliform Bacteria. Three of the four statements must be correct.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 4 items. You must solve 3 items correctly to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, start your progress check.

DIRECTIONS:

Complete each of the following statements concerning the coliform test.

1. When testing for coliform bacteria you must be sure to use _________ sample bottles.

2. The multiple-tube fermentation method is based on the appearance of _____________ _______________ in small vials or tubes.

3. Test results for the multiple tube fermentation method are expressed as a _______ _________ _________ index.

4. If coliforms are present, they are an indicator of possible ______________ contamination.

-- STOP --

Before proceeding any further have the instructor check your answers.

_______________ Instructor's Initials

WASTEWATER ANALYSIS

OBJECTIVE:

Given information, laboratory equipment, and a wastewater sample, perform a Biochemical Oxygen Demand test. No more than two instructor assists are allowed.

REFERENCE/MATERIAL/EQUIPMENT:

Misc Glassware
Misc Reagents
Lab Station

Lab Manual
Incubator
Wastewater samples

INSTRUCTIONS:

1. This progress check consists of 2 laboratory tests. You must correctly perform each test to receive a satisfactory rating.

2. You are allowed two instructor assists.

3. When you have completed the progress check, return it to your instructor.

4. If you have no questions, start your progress check.

DIRECTIONS:

Follow the directions on pages 6, 7, 8, and 9 in your lab manual and test a wastewater sample for dissolved oxygen and BOD.

DO = ______________________ mg/L

BOD = ____________________ mg/L

-- STOP --

Before proceeding any further have the instructor check your answers.

________________ Instructor's Initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-11-7f
June 1986

WASTEWATER ANALYSIS

OBJECTIVE:

Given information related to wastewater analysis and five facts concerning the purpose of Chemical Oxygen Demand (COD) testing method, match the facts with the information. Three of the five must be correct.

REFERENCE/MATERIAL/EQUIPMENT:

None

INSTRUCTIONS:

1. This progress check consists of 5 items. You must solve 3 items correctly to receive a satisfactory rating.

2. When you have completed the progress check, return it to your instructor.

3. If you have no questions, start your progress check.

DIRECTIONS:

Match the statement in Column II to the statement in Column I. The statements in Column II may be used once, more than once, or not at all.

COLUMN I

1. ( ) The short time required is
2. ( ) COD measures
3. ( ) COD readings will be
4. ( ) A reagent used in the COD test is
5. ( ) COD is measuraed from what kind of sample

COLUMN II

a. The strength of wastewater
b. Lower than BOD
c. A disadvantage of COD
d. Ferrous ammonium sulfate
e. Composite
f. Grab
g. An advantage of COD
h. Higher than BOD
i. Potassium iodide
j. The strength of oxygen

-- STOP --

Before proceeding any further have the instructor check your answers.

_________________ Instructor's Initials

Technical Training

LABORATORY MANUAL

JUNE 1984

3700 TECHNICAL TRAINING WING
3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

PREFACE

This manual has been written for use in the 566X1. Its purpose is to aid you in acquiring the basic knowledges and skills needed to perform the laboratory tests used in water and wastewater analyses.

The tests and procedures used in this manual have been selected from several sources and modified to meet classroom conditions.

For specific instructions on field testing, you should refer to Analysis of Water and Sewage, by Theroux, Eldridge, and Mullman; Standard Methods for the Examination of Water and Wastewater, 15th ed., American Public Health Association; manufacturer's instructions; or other authorized laboratory manuals.

You will not perform every test listed in this laboratory manual. You will do only those tests that fall within the scope and proficiency level of the course you are attending.

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Supersedes ALL 566X1 COURSES LABORATORY MANUAL, January 1981

GENERAL LABORATORY PROCEDURES

The following procedures are applicable to all laboratory tests:

1. Observe all safety rules applicable to the test (see Laboratory Safety Rules).
2. Select chemicals and equipment needed for the test.
3. Clean all equipment before using. NOTE: Do not use transfer pipet for more than one reagent unless cleaned before each use.
4. Collect sample as needed for test.
5. Perform the test.
6. Compute results.
7. Record results. NOTE: Results are not correct unless recorded in proper units.
8. Clean equipment and work area.
9. Store equipment as directed.

LABORATORY SAFETY RULES

The following safety rules must be observed when working in the laboratory or during field testing:

1. Wear and use necessary safety equipment. NOTE: Aprons will always be worn while working in the laboratory.

2. Remove jewelry before entering laboratory area.

3. NEVER mix chemicals at random.

4. Smell chemicals slowly.

5. Keep work area clean at all times.

6. Do NOT use chemicals or reagents which are not properly identified.

7. If chemicals are spilled on you, wash immediately with water.

   NOTE: If hands feel slick or burn, wash them.

8. Do NOT use chipped or cracked glassware.

9. Do NOT heat closed containers.

10. Do NOT engage in horseplay.

11. Always add chemicals to water; NEVER add water to chemicals.

12. Do NOT taste chemicals.

COLLECTING AND LABELING WATER AND WASTEWATER SAMPLES

The following questions and procedures will assist you in learning the process of collecting and labeling water and wastewater samples.

QUESTIONS

1. What is the purpose of sampling?

2. Why should samples be labeled?

3. What are grab samples?

4. What is a composite sample?

5. What areas of a lake, stream, or spring should be avoided when collecting water samples?

6. List the steps required to collect a water sample from a lake.

PROCEDURES

1. Collect water sample for laboratory analysis. Sample will be taken from an area designated by the instructor.
    a. Obtain a clear 300 mL bottle from the lab.
    b. Go to sampling point designated by the instructor and thoroughly flush the sampling line.
    c. Rinse sample bottle thoroughly with water to be tested.
    d. Adjust sampling line to fill container.
    e. Using a slow, steady flow, fill sample bottle to overflowing.
    f. Turn off tap and immediately cap sample bottle.
    g. Label sample giving the following information:
        (1) Name of collector
        (2) Date of collection
        (3) Sampling point

        (4) Source of water
        (5) Temperature of sample
        (6) Type of analysis needed

    h. Take sample to lab for testing and analysis.

2. Collect and label a wastewater sample for laboratory test.
    a. Obtain a clean wide mouth container (1000 ML beaker) from lab.
    b. Obtain a precollected sample from jar located in refrigerator.
    c. Label sample, giving the following information.
        (1) Name of collector
        (2) Date of collection
        (3) Place sample taken
        (4) Source of water
        (5) Temperature of sample
        (6) Type of analysis needed
    d. Take sample to lab for testing and analysis.

ACIDITY TEST

Purpose of Test: To determine the amount of free mineral acidity (FMA) and total acidity present in a sample.

Method of Testing: Volumetric titration using color indicators to determine the end point.

Principles of Test:

1. Free mineral acids in a water solution will cause a pH of 4.5 or below.

2. In the absence of FMAs or after their removal, the weak acid will cause a pH above 4.5 and below 8.3.

3. Using an alkaline reagent, the FMAs are neutralized. Methyl orange is used as the end point indicator. The weak acids are then neutralized, using phenolphthalein as the end point indicator.

4. The basic reactions are $NaOH + H_2SO_4 \qquad Na_2SO_4 + H_2O$ (FMA neutralization) and

   $NaOH + H_2CO_3 \qquad NaHCO_3 + H_2O$ (weak acid neutralization).

Equipment:

1. Buret
2. Graduated cylinder
3. Erlenmeyer flask

Reagents:

1. 0.02N sodium hydroxide
2. Methyl orange indicator
3. Phenolphthalein indicator
4. 0.1N sodium thiosulfate

Procedure:

A. Free mineral acidity

1. For comparison purposes, measure 50 mL of distilled water into another Erlenmeyer flask and add 3 drops of methyl orange. This is a straw yellow color. This straw yellow is the endpoint of the coming titration. Keep this flask and water for comparison.

2. Measure 50 mL of the sample into a graduated cylinder and pour it into an Erlenmeyer flask.

3. If the water sample contains clorine add one drop of sodium thiosulfate ($Na_2S_2O_3$) to the sample.

4. Add three drops of methyl orange indicator. If the sample turns straw yellow there is no acid (FMA) in the sample, go to step 8 and record FMA as 0 mg/L. If the sample turns pink there is FMA. Continue the test.

5. Fill a buret with .02N NaOH.

6. If the sample from step 4 is even slightly orange or pink, titrate with the .02N NaOH while stirring. Titrate over a sheet of white paper until end point color of straw yellow is reached.

7. Read the buret and multiply by 20 to give the mg/L of FMA. Save this sample for the total acidity test which follows.

   FMA = 20 x mL of NaOH titrant

8. Record the mg/L below:

   Special Sample FMA = ________________________________ mg/L.

9. Continue testing this sample below Do not refill the buret or toss the sample away.

B. Total Acidity

1. Add 3 drops of phenolphthalein to the water sample used above.

   NOTE: If a pink or orange color appears, the total acidity and the FMA are the same.

2. If no color change appears, titrate further with NaOH to a pink or an orange color.

3. Read the buret and multiply the mL of the NaOH used by 20.

4. Record the total acidity

   Special Sample total acidity __________________________ mg/L.

5. To find carbonic acid content subtract FMA from total acidity.

   Carbonic acid content = ________________________________mg/L.

ALKALINITY

Purpose of Test: To determine the amount of alkaline compounds in a sample, the acid neutralizing capacity, and the type of alkaline anions present.

Method of Testing: Volumetric titration using pH or color indicators to determine end point.

Principles of Test:

1. The anions which normally cause alkalinity in water are hydroxides $(OH)^-$, carbonates $(CO_3)^=$ and bicarbonates $(HCO_3)^-$.

2. Due to the ionization constants of the CO_2 compounds the following conditions exist:

    a. Where significant hydroxides $(OH)^-$ exist, all CO_2 would be in the carbonate $(CO_3)^=$ form and no bicarbonates $(HCO_3)^-$ would be present.

    b. In the absence of hydroxides $(OH)^-$ and with a pH above 8.3, the CO_2 would be in the form of CO_3.

    c. At a pH of 8.3 all CO_2 is $(HCO_3)^-$.

    d. Between pH of 4.8 and 8.3, the CO_2 is in the form of $(HCO_3)^-$ and $H_2(CO_3)$ (Carbonic acid).

    e. At or below a pH 4.8, all CO_2 is in the form of carbonic acid, $H_2(CO_3)$.

3. The alkalinity due to $(OH)^-$ and 1/2 of the alkalinity due to carbonates is neutralized with 0.02N sulfuric acid at a pH of 8.3. This amount of alkalinity is computed and reported as "P" alkalinity

4. The remaining 1/2 carbonate alkalinity and the total bicarbonate alkalinity is neutralized at a pH of 4.8, and the total amount of acid is used to compute the total alkalinity

5. The $(OH)^-$ and $(HCO_3)^-$ alkalinity is computed using a chart based on the above stated conditions and their relationship to "P" and "M" alkalinity.

Equipment:

1. Buret
2. Graduated cylinder
3. Erlenmeyer flask or casserole

Reagents:

1. 0.02N sulfuric acid
2. Phenolphthalein indicator
3. Mixed reagent
4. 0.1N sodium thiosulfate

Procedure:

1. Measure 50 mL of the sample into a graduated cylinder and pour it into an Erlenmeyer flask.

2. Add 1 drop of 0.1N sodium thiosulfate to remove residual chlorine and to prevent bleaching of the indicators.

3. Add 3 drops of phenolphthalein indicator.

   a. If the sample turns pink "P" alkalinity is present. Proceed to step 4.

   b. If the sample turns clear, no "P" alkalinity is present. Go to step 5 and record mL acid for "P" as 0 and proceed to step 6.

4. Titrate with 0.02N sulfuric acid until pink color fades away.

5. Record ml. acid for "P" = ____________________.

6. Add 3 drops mixed reagent indicator.

   a. If the sample turns light pink-gray with bluish cast, "M" alkalinity is the same as "P" alkalinity. Record mL acid for "M" = ____________________. Proceed to step 8.

   b. If the sample does not turn light pink-gray with bluish cast proceed to step 7.

7. Continue the titration until the sample turns light pink-gray with bluish

   cast. Record mL acid for "M" = ____________________.

8. Compute and record "P" and "M" alkalinity as follows:

   The mL acid for "P" x 20 = __________ mg/L "P" alkalinity as $CaCO_3$

   The mL acid for "M" x 20 = __________ mg/L "M" alkalinity as $CaCO_3$

9. Using "P" and "M" determined and relationship table below, compute and record $(OH)^-$, $(CO_3)^=$ and $(HCO_3)^-$ alkalinity of sample.

CONDITIONS OF ALKALINITY	HYDRATE $(OH)^-$	CARBONATE $(CO_3)^=$	BICARBONATE $(HCO_3)^-$
P = 0	0	0	M
P = M	M	0	0
P = 1/2M	0	M	0
P = is greater than 1/2M	2P-M	2(M-P)	0
P = is less than 1/2M	0	2P	M-2P

a. $(OH)^-$ alkalinity = ____________ mg/L as $CaCO_3$

b. $(CO_3)^=$ alkalinity = ____________ mg/L as $CaCO_3$

c. $(HCO_3)^-$ alkalinity = ____________ mg/L as $CaCO_3$

BIO-CHEMICAL OXYGEN DEMAND (BOD)

Purpose of Test: To determine the oxygen required by the microscopic organisms in the sample to oxidize the organic matter in a sample.

Method of Testing: Analysis before and after incubation to determine the amount of oxygen present.

Principles of Test:

1. Aerobic organisms will decompose organic material in wastewater if adequate dissolved oxygen is present. The oxygen used will be proportional to the material decomposed.

2. Adequate oxygen is insured by diluting the sample with special water saturated with oxygen. The amount of dilution depends on the strength of the sewage sample as follows:

   a. Raw sewage - 2% (20 mL. per 1000 mL. total dilution)

   b. Settled sewge - 3% (30 mL. per 1000 mL. total dilution)

   c. Plant effluent - 5% (50 mL. per 1000 mL. total dilution)

   d. Stream sample - 25 to 100% (depending on condition of stream (250 mL per 1000 mL total dilution)

3. The sample is incubated at 20°C. to provide uniform conditions for bacterial growth and give uniform results for reporting.

4. The incubation covers 5 days, and the results as reported imply that it is a 5 day BOD unless otherwise stated. The 5 day BOD actually represents 68% of the total BOD.

Equipment:

1. Two BOD bottles
2. Graduated cylinder (100 mL)
3. Erlenmeyer flask
4. Three pipets
5. Buret
6. Incubator at 20°C.

Reagents

1. Dilution water
2. Manganous sulfate
3. Alkali iodide azide
4. Concentrated sulfuric acid
5. 0.025N sodium thiosulfate
6. Starch solution

Procedures: B.O.D. Test for Wastewater

1. Fill two 300 mL BOD bottles approximtely half full with dilution water.

2. Add wastewater to both bottles:

   a. For "RAW" sample - add 6 mL (2% dilution).

   b. For "SETTLED" sample - add 12 mL (4% dilution).

   c. For "FINAL" sample - add 24 mL (8% dilution).

3. Add additional dilution water until bottle is filled half way into ground glass area or neck (where stopper fits).

4. Insert glass stoppers. Make sure that there is no trapped air under the stopper. Confirm water seal in neck of BOD bottle to prevent air from entering sample. Cover top of BOD bottle with plastic cap.

5. Place one sample in incubator and incubate for 5 days at 20°C.

6. Perform the DO test on other sample (designate test results as "DO #1").

7. After 5 days, perform DO test on incubated sample (designate test results as "DO #2").

8. Calculate mg/L BOD using this formula:

$$\text{mg/L BOD} = \frac{\text{DO \#1} - \text{DO \#2}}{\text{decimal value of percent dilution used}}$$

DISSOLVED OXYGEN

Purpose of Test: To determine the dissolved oxygen in a water or wastewater sample.

Method of Testing: Volumetric Titration.

Principles of Test:

1. Manganous sulfate reacts in an alkaline solution to form manganous hydroxide (white precipitate if oxygen is absent).

2. Oxygen will react with the manganous hydroxide to form a brown precipitate of manganic basic oxide.

3. Upon the addition of sulfuric acid, the brown precipitate dissolves forming manganic sulfate.

4. The manganic sulfate immediately reacts with the potassium iodide to form potassium sulfate and free iodine. The iodine released is proportional to the D.O. in the sample.

5. The iodine is titrated with sodium thiosulfate as the reagent and starch as the end point indicator.

Equipment:

1. BOD bottle (300 mL)
2. Three pipets
3. Buret
4. Erlenmeyer flask
5. Suction bulb

Reagents:

1. Manganous sulfate
2. Alkali iodide azide
3. Concentrated sulfuric acid
4. 0.025N sodium thiosulfate
5. Starch solution

Procedure:

1. Fill BOD bottle with sample. Observe rules for taking sample for dissolved gases.

2. Add 1 mL manganous sulfate. NOTE: Add each reagent with a clean pipet. Hold pipet tips just above liquid surface when adding reagents.

3. Add 1 mL of alkali iodide azide.

4. Stopper bottle, pour off excess solution, and mix contents by shaking the bottle. Allow precipitant to settle half way.

5. Add 1 mL concentrated sulfuric acid. CAUTION: Acid is dangerous. Handle carefully.

6. Stopper bottle, pour off excess, mix by shaking the bottle all the floc is dissolved.

7. Measure 100 mL of the treated sample in a graduated cylinder and pour into an Erlenmeyer flask.

   NOTE If extreme accuracy is required see Standard Methods.

8. Titrate with 0.025N sodium thiosulfate until yellow color becomes a pale, light yellow.

9. Add a few drops of starch solution. Sample will turn blue.

10. Continue titration to the _first_ disappearance of the blue color.

11. Read buret and record: Sodium thiosulfate used = ________ mL.

12. Compute mg/L as follows:

    mL sodium thiosulfate times 2 = mg/L D.O.

13. Record results as ____________ mg/L D.O.

CHLORIDE

Purpose of Test: To determine the amount of chlorides in the water.

Method of Testing: Selective precipitation by volumetric titration using the formation of insoluble silver chloride.

Principles of Test:

1. At a pH between 7 and 10 silver nitrate will precipitate the chlorides as silver chloride.

2. Once the chlorides are precipitated, a slight excess of silver nitrate will react with potassium chromate (yellow indicator) to precipitate silver chromate which is red.

3. Due to the presence of the white silver chloride precipitant, the yellow potassium chromate and the red silver chromate, the end point color is determined by using a distilled water blank.

Equipment:

1. Graduated cylinder
2. 2 Casseroles
3. Buret
4. Stirring rod

Reagents:

1. Phenolphthalein indicator
2. 0.0282N silver nitrate
   NOTE. Silver nitrate should be standardized daily and calculations made accordingly.
3. 0.1N sulfuric acid
4. 0.1N sodium hydroxide
5. Potassium chromate indicator solution

Procedure:

1. Measure 50 mL of distilled water in a graduated cylinder and pour into a casserole.

2. Add 1 mL of potassium chromate indicator.

3. Titrate with silver nitrate until a reddish color develops. Record mL of reagent for blank __________. Save this blank for determining the end point of sample titrated.

4. Measure 50 mL of sample in a graduated cylinder and pour into a second casserole.

5. Add 2 drops of phenolphtalein and adjust pH as follows:

   a. If sample turns pink add 0.1N sulfuric acid until the pink color fades away and continue to step 6.

   b. If sample turns clear add 0.1N sodium hydroxide, drop at a time, until a slight pink color develops and continue to step 6

6. Add 1 mL of potassium chromate indicator.

7. Titrate with silver nitrate reagent until color similar to the blank is reached. Titrated sample will not be a distinct red, it will be pinkish white or pinkish yellow.

8. Compute results as follows:

   mg/L chloride = mL reagent for sample - mL reagent for blank X 20.

CHLORINE RESIDUAL TESTING (DPD METHOD)

Purpose of Test: To determine the chlorine residual in a water sample.

Method of Testing: Visual color comparison.

Principles of Test:

1. Chlorine is added to drinking water, swimming pools and wastewater to kill the harmful bacteria. The chlorine in water is "free available chlorine", or it can combine with nitrogen compounds to form "combined chlorine." "Total chlorine residual" is the total of free available and combined chlorine residuals.

2. The only method approved to determine chlorine in a water sample is the DPD method. (N, N- Diethyl - p - Phenylenediamine).

3. At a pH of 6.2 to 6.5 the DPD reagent will react with the "free available" chlorine and forms a red color. The tint or shade of that red color is proportional to the amount of chlorine in the sample. A residual of less than 4 mg/L is measured this way. Greater than 4 mg/L makes a yellow color.

Procedures For Hellige Visual Color Comparator

Equipment:

1. Hellige Color Comparator which includes:
    a. Color Comparator (body)
    b. DPD Chlorine disc
    c. Two test tubes

2. Small beaker for sample

Reagent:

Hellige DPD Tablets #1 and #3 (in box, foil-wrapped).

Procedure A. Free available chlorine

1. Fill the left-hand test tube to 10 mL line with the water sample to be analyzed. Rinse the right-hand tube with part of the sample water leaving just enough sample to cover the tablet.

2. Add one (1) DPD #1 tablet and crush it using a plastic stirring rod.

3. Remove the stirring rod. Fill the test tube to the 10 mL line with more sample water and mix by inverting the sample tube several times until the DPD tablet is dissolved.

4. Place the DPD disc in the comparator, hold the unit securely and rotate the disc so that each standard color appears in the viewer or sight until the color matches or nearly matches the color of the water sample being tested. Read the number in the upper-right side of the unit to record the mg/L of "free available" chlorine.

Procedure B   Total Residual Chlorine

To obtain "total residual chlorine", follow procedure A for "free available chlorine" using DPD tablet #1 and then add one (1) DPD tablet #3 to the sample and read the ppm as in the previous step.

Record your results:

Free available residual _______________mg/L

Total available residual _______________mg/L

PROCEDURE FOR HACH VISUAL COLOR COMPARATOR

Equipment

1. Hach color comparator which includes:
    a. Color comparator (body)
    b. DPD color disc
    c. Two test tubes and caps
2. Fingernail clippers

Reagent:

1 DPD - "Free" chlorine powder pillows, for 5 mL sample
1 DPD - "Total" chlorine powder pillows, for 5 mL sample

Procedure A. Free available chlorine

1. Fill one test tube with clear water to the 5-mL mark and place the tube in the top left opening of the comparator.

2. Fill the second test tube with the water sample to the 5-mL mark.

3. Now add one DPD "Free available" chlorine powder pillow contents to the water sample to be measured. Insert the rubber cap in the test tube, mix the sample by swirling. Place the tube in the top right opening of the comparator.

4. Hold the comparator with its contents up to a lighted area and view through the sight or opening in the front of the comparator. Turn the color disc until the colors match.

5. IMPORTANT   Within one (1) minute read the mg/L "free" chlorine reading from the scale window at the bottom center of the comparator.

Procedure B. Total residual chlorine

1. Fill one test tube with clear water to the 5-mL mark and place the tube in the top left opening of the comparator.

2. Fill the second test tube with the water sample to the 5-mL mark.

3. Now add one DPD "total chlorine" powder pillow contents to the water sample to be measured. Insert the rubber cap in the test tube, mix the sample by swirling and let stand for three (3) minutes. Then place the test tube in the top right opening of the comparator.

4. Hold the comparator with its contents up to a lighted area and view through the sight or opening in the front of the comparator. Turn the color disc until the colors match - read the mg/L total chlorine from the scale window.

Record your results:

Free available residual ________________ mg/L

Total available residual ________________ mg/L

NOTE: The test procedures for chlorine using the Hach visual color comparator can be found on the inside lid of the Hach kit.

PROCEDURES FOR HACH COLORIMETER

Equipment

1. Hach DR "Direct Reading" Colorimeter unit which includes:
    a. Colorimeter body with percision working components
    b. Sample cell
    c. Insertable meter scales
    d. Color filters
2. Cutting tool (knife, scissors, fingernail clipper)

Reagent:

1 DPD - Free Chlorine Reagent Powder Pillows, for 25 mL sample
1 DPD - Total Chlorine Reagent Powder Pillows, for 25 mL sample

Procedure:

Instructions for performing both "Free" and "Total" chlorine residual for the Hach colorimeter are found in the manufacturer's manual located in your lab station drawer. Use this manual to perform the chlorine tests.

Record your results:

Free available residual ____________________mg/L

Total available residual ____________________mg/L

HARDNESS (EDTA)

Purpose of Test: To determine the total amount of hardness as $CaCO_3$ equivalent, that portion caused by Ca and Mg.

Method of Testing: Volumetric titration with EDTA to form complex Ca and Mg compounds. Organic dyes are used as end point indicators.

Principles of Test:

1. In a buffered solution, using "Total Hardness Buffer," Ca and Mg will cause a "Total Hardness Indicator" dye to give a red color to the solution.
2. EDTA added to solution will form a complex ion with the Ca and Mg and a slight excess of EDTA will turn the solution blue.
3. In a solution buffered with "Calcium Buffer" the Mg is rendered inactive and the EDTA plus Ca will cause "Calcium Hardness Indicator" dye to turn pink.
4. EDTA added to this solution will form a complex ion with Ca and a slight excess will turn the solution a purple color.

Equipment:

1. Buret
2. Casserole
3. Graduated cylinder
4. Pipet
5. Stirring rod
6. Chemical scoop

Reagents:

1. 0.02N EDTA Hardness Solution
2. Total hardness buffer
3. Total hardness indicator
4. Calcium hardness buffer
5. Calcium hardness indicator

Procedure for Total Hardness:

1. Measure 50 mL of sample and transfer to a casserole.
2. Add 1.0 mL of Total Hardness buffer and stir to mix.
3. Add one chemical scoop of total hardness indicator and stir until dissolved.
4. Titrate with EDTA to a blue color (end point) and record the number of mL of EDTA used. EDTA for total hardness = ________________ mL

Procedures for Calcium hardness:

5. Measure an additional 50 mL of sample and transfer to a clean casserole.
6. Add 2 mL of calcium buffer solution.
7. Add two chemical scoops of calcium hardness indicator and stir until dissolved.

8. Titrate with EDTA until a purple color (end point) is reached and record mL of EDTA used. EDTA for calcium hardness = ______ mL

9. Compute mg/L Total Hardness, Calcium Hardness and Magnesium Hardness as follows:

   a. The mL EDTA for Total Hardness X 20 = ____________________ mg/L Total Hardness as $CaCO_3$.

   b. The mL EDTA for Calcium Hardness X 20 = __________________ mg/L Calcium Hardness as $CaCO_3$.

   c. Total Hardness - Calcium Hardness = ___________________mg/L Mg Hardness.

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JAR TEST

Purpose of Test: To determine optimum day to day chemical dosage for coagulation and flocculation of a water supply when experience or a series of similar tests has established that the best coagulant is ferric chloride, the optimum pH is 8.5 to 11, and that soda ash is the best source of alkalinity.

Method of Testing: Trial Treatment.

Principles of Test:

1. When the proper coagulant, optimum pH, and source of alkalinity for a given water is known, the changes in coagulant dosage to meet day to day changes in the water are determined by adding sufficient alkalinity and progressive amounts of coagulant, mixing, and observing the results of these different dosages.

2. In this test, soda ash is added to adjust the pH of 6-one liter samples. Then additional soda ash is added to each sample, in proportion to the amount of coagulant to be added, to prevent lowering the pH when the coagulant is added.

3. Ferric chloride coagulant is added to each of the samples in progressive amounts and mixed.

4. Mixing time and rates are controlled to duplicate the conditions of the plant being used.

5. The optimum chemical dosage is the one using the least amount of chemicals which will produce a pinhead size floc that will settle in 30 minutes leaving a turbidity of less than 10 NTUs (will appear clear, for classroom work).

Equipment:

1. Six one-liter beakers
2. Graduated cylinder (1000 ml.)
3. Laboratory stirrer
4. Pipet

Reagents:

1. Phenolphthalein indicator solution

2. Standard ferric chloride solution

   a. Weigh 10 grams of ferric chloride

   b. Dissolve in 1 liter of demineralized water

   c. Shake immediately

   d. Each 0.1 mL of this solution represents a dosage of 1.0 mg/L when added to a one liter water sample. Each 1.0 mL of solution represents a dosage of 10.0 mg/L in one liter of sample.

3. Standard soda ash solution (follow procedures as given to make up ferric chloride solution).

Procedure:

1. Determine soda ash needed for pH adjustment as follows:
   a. Measure 1 liter of sample and pour it into beaker.
   b. Add 5 drops of phenolphthalein.
   c. Add soda ash solution 1 mL at a time until sample turns dark pink or red.
   d. Record mL of soda ash solution used for pH adjustment in chart below. Discard this sample.
2. Add 1 liter of sample to each of the 6 one liter beakers.
3. Adjust pH by adding soda ash solution to each beaker in the amount determined in step 1. Record amount used in chart below
4. Add additional soda ash solution to sample beakers as follows:

   Beaker #1 - 0.6 mL; #2 - 1.2 mL; #3 - 2.4 mL; #4 - 3.6 mL; #5 - 4.8 mL; #6 - 6 mL.
5. Place beakers under mixer then turn on mixer. Adjust mixer paddles and beaker to maximuim turbulence at 80 RPM (Revolutions Per Minute).
6. Add ferric chloride solution as follows:

   Beaker #1 - 0.5 mL; #2 - 1 mL; #3 - 2 mL; #4 - 3 mL; #5 - 4 mL; #6 - 5 mL.
7. Mix at 80 RPM for 2 minutes.
8. Turn mixer control to 20 RPM and mix for 30 minutes.
9. Turn off mixer and allow to settle for 30 minutes.
10. Observe results and record as A (for acceptable) or NA (not acceptable).
11. Review chart to determine acceptable treatment with the least amount of chemicals used.
12. Compute dosages as follows:
    a. The mL ferric chloride X 10 = mg/L ferric chloride.
    b. The mL ferric chloride X 10 X 8.34 = lbs ferric chloride per M-gal.
    c. Total mL soda ash X 10 = mg/L soda ash.
    d. Total mL soda ash X 10 X 8.34 = lbs soda ash per M-gal.

TREATMENT DOSAGE CHART

Sample No.	1	2	3	4	5	6
Soda Ash for pH adj (mL.)						
Soda Ash for $FeCl_3$						
Total soda ash						
The mL $FeCl_3$						
Total Chemical						

pH (ELECTRIC METER)

Purpose of Test: To measure the free hydrogen ion concentration (pH) of a water sample as a measurement of its degree of acidity or alkalinity.

Method of Testing: Electric pH Meter

Principles of Test:

1. Measurement of pH is accomplished by determining the potential developed by an electrical cell.
2. The anode half cell or reference electrode consists of a glass tube containing mercury mercurous chloride immersed in a saturated KCl solution. The tube has a porous tip to allow a liquid junction between the half cell and the sample. The half cell has a constant potential.
3. The cathode half cell electrode consists of a glass electrode which is sensitive to the hydrogen ion in the sample. The potential of the half cell varies with the hydrogen ion concentration of the solution.
4. Since the potential of the reference electrode is constant, the potential of the cell depends on the hydrogen ion concentration of the sample.
5. The black scale of the meter is calibrated to read the pH, negative log of the hydrogen ion concentration, equivalent to the electrical potential produced by the cell.
6. Due to the change of sensitivity of the meter at different pHs, the unit must be standardized with a buffered solution of a known pH, before testing the sample.

Equipment:

1. Zeromatic pH meter
2. 50 mL beaker (for buffer)
3. 150 mL beaker (for distilled water rinse and sample)

Reagents:

1. pH buffer solution (pH of solution near estimated pH of sample)

Procedure:

1. Preparing the meter

   a. Remove the cover.

   b. Depress the manual and standby buttons on the meter.

   CAUTION: Never remove the electrode from water with the "READ" button depressed.

   c. Electrode should be handled carefully and kept clean since they are very are very sensitive to scratches and contaminating ions.

2. Standardizing the meter

   a. Pour approximately 1 inch of pH (4.0, 7.0, or 10.0) buffer into the 50 mL beaker.

   b. Submerge electrodes in this buffer.

   CAUTION: Do not allow probe to come in contact with the bottom of the beaker.

c. Set temperature knob to room temperature.

d. Depress "READ" button.

e. Turn "Standardize" knob until the meter indicates pH of the buffer (4.0, 7.0, or 10.0) on the black scale.

NOTE: The indicator may tend to drift. Allow time for it to stabilize before reading.

f. Depress standby button.

3. Determining pH of sample.

a. Using 150 mL beaker and distilled water rinse the electrodes three times using fresh distilled water each time.

b. Rinse beaker and electrode with sample and discard this water.

c. Refill beaker with sample and submerge probe approximately one inch.

d. Obtain temperature of sample and set temperature knob on meter to that of the sample.

e. Depress "READ" button and allow indicator to stabilize.

f. Push "Standby" button down.

g. Read the meter and record to the nearest 0.1 pH.

Sample pH = ______________________________.

h. If equipment is to be left in the standby position, rinse electrode with distilled water and leave them out of the water solution.

4. Storing meter

a. Unplug the meter.

b. Remove electrode from water, and rinse with distilled water.

c. Cover the meter.

pH (HELLIGE COLOR COMPARATOR)

Purpose of Test: To determine the hydrogen ion concentration of a water sample as a measure of its degree of acidity or alkalinity.

Method of Testing: Visual color comparison using the Hellige Color Comparator.

Principles of Test:

1. Certain organic dyes, pH indicators, give a specific color to a water sample at or below a certain pH and change to another color at or above a higher pH. When the pH is between the high and low ranges, the color or shade of color will vary with the pH. The pH range and color produced are specific to the indicator used.

2. The color produced when an indicator is added to the sample is matched to a standard color on a color disc which is specific to the indicator used.

Equipment:

1. Hellige Color Comparator which includes:
    a. Color comparator (body)
    b. Two test tubes
    c. Color discs for following indicators:

        a. Phenol Red
        b. Chlorophenol Red
        c. Bromocresol Green

Reagents:

1. Phenol Red indicator
2. Chlorophenol Red indicator
3. Bromocresol Green indicator

Procedure:

1. Fill the left test tube to the 10 mL line with the water sampLe to be analyzed. Rinse the right tube with part of the sample water.

2. Add 0.5 mL of the chlorophenol red color indicator to be used. Fill with sample water to the 10 mL mark. Mix by inverting the sample tube several times.

3. Place the color disc for chlorophenol red in the comparator, hold the unit securely and rotate the disc so that each standard color appears in the viewer or sight until the color matches or nearly matches the color of the water sample being tested.

4. Read the pH from the number in the upper-right side of the unit and proceed as follows:

    a. If the pH is less than 5.8 but greater than 5.2, report this as the pH of the sample. Proceed to step 12.

    b. If the pH is 5.2, proceed to step 5.

    c. If the pH is 6.8, proceed to step 7.

5. Repeat steps 1 thru 3 substituting bromocresol green indicator and disc for chlorophenol red and indicator disc.

6. Make color match and report as follows:

    a. If pH is greater than 3.8 report it as the pH of sample.

    b. If pH is 3.8 report "3.8 or below" as the pH of the sample. Omit steps 7 and 8.

7. Repeat steps 1 thru 3 substituting phenol red indicator and phenol red disc for chlorophenol red indicator disc

8. Make color match and report as follows:

   a. If pH is below 8.4 report it as the pH of sample.

   b. If pH is 8.4 report pH of sample as "8.4 or above."

9. Record results:

   pH of sample:

DISSOLVED SOLIDS

Purpose of Test: To determine that portion of total solids in a sample which is dissolved.

Method of Testing: The normal procedure is to perform a total solids test and a suspended solids test and subtract the suspended solids from total solids.

Total solids in mg/L
- Suspended solids in mg/L
Dissolved solids in mg/L

Example: 65 mg/L (total solids)
- 42 mg/L (suspended solids)
23 mg/L (dissolved solids)

SETTLEABLE SOLIDS

Purpose of Test: To determine the volume of solids which will settle out of a wastewater sample in order to determine the efficiency of sedimentation tanks.

Method of Testing: Settling sample in an Imhoff cone for a given period of time.

Principles of Testing:

1. Solids which will settle in a settling tank with normal detention time should settle under still conditions in one hour.

2. Slight agitation at the end of the 45 minutes will allow solids which stick to the cone to settle down in 15 minutes.

3. The Imhoff cone contains 1000 mL and the bottom is graduated in mL. The results are expressed as mL per liter.

Equipment:

1. Imhoff cone
2. Imhoff cone stand

Procedure:

1. Fill Imhoff cone to the 1000 mL mark with well mixed sample and place in the stand.

2. Allow sample to stand for 45 minutes.

3. Lift cone and rotate back and forth 2 or 3 times.

4. Allow to stand for 15 minutes.

5. Read the cone at solids level and record as follows: ______________ mL per liter settleable solids.

SUSPENDED SOLIDS

Purpose of Test: To determine that portion of solids in a wastewater sample which are not dissolved.

Method of Testing: Gravimetric following filtration.

Principles of Test:

1. Suspended solids will be retained on a suitable filter and dissolved solids will pass through.
2. After drying and weighing, the weight of suspended solids is converted to mg/L using the following formula:

$$\frac{\text{Wt X 1,000,000}}{\text{mL sample}} = \text{mg/L}$$

Equipment

1. Graduated cylinder
2. Gooch crucible
3. Suction apparatus
4. Drying oven
5. Tongs
6. Dessicator
7. Analytical balance

Reagents and Supplies:

1. Glass filter pad

Procedure:

1. Place Gooch crucible on suction flask and insert filter pad.
    a. Apply suction to flask.
    b. Wash filter with three 20 mL portions of distilled water. Vacuum filter until all traces of water is removed.
2. Place crucible with pad in drying oven at 103°C. for one hour.
3. Remove crucible from oven, place in dessicator to cool (for at least 15 minutes).

    CAUTION: Tongs must be used to handle hot equipment and also to prevent contamination from oils and greases on hands.

4. Weigh crucible with pad. Record weight on next page.
5. Measure 25 mL of raw wastewater or 50 mL of settled wastewater or 100 mL of plant effluent in graduated cylinder.
    a. Place crucible on filter apparatus and apply vacuum.
    b. Filter measured sample.
    c. After filtering sample, rinse graduated cylinder used to measure sample with three 10mL volumes of distilled water and vacuum the rinse water through filter pad.
6. Dry filter and residue in oven for one hour.

7. Cool in dessicator for 15 minutes.

8. Weigh and record the weight.

9. Compute weight of solids as follows: Weight of crucible, pad and solids (step 8) minus weight of crucible and pad (step 4) = weight of suspended solids.

Step 8 - Weight of crucible, pad and solids = ____________________ g

Step 4 - Weight of crucible and pad = ____________________ g

Weight of suspended solids = ____________________ g

10. Convert weight of suspended solids to mg/L and record results. See principles of test No. 2.

TOTAL SOLIDS

Purpose of Test: To determine the total solids content of wastewater, sludge or water samples.

Method of Testing: Gravimetric determination following drying.

Principles of Test:

1. Most of the water is removed from the sample by a steam bath to prevent solids from caking to drying dish or forming moist pockets which are hard to dry.
2. Drying in an oven at 103°C. will remove remaining free water without causing volatilization of the solids.

Equipment:

1. Evaporating dish
2. Graduated cylinder or pan scales
3. Analytical balance
4. Drying oven
5. Tongs
6. Dessicator
7. Steam bath

Procedure:

1. If sample contains small amounts of solids, place clean evaporating dish in oven and dry for one hour. (Dish used for sludge samples does not need oven drying).
2. Remove dish from oven and let cool in dessicator.

   CAUTION: Use tongs when handling equipment from oven or from dessicator to prevent burns and to prevent contamination of equipment.

3. Weigh clean dry dish on analytical balance and record weight in step 9.
4. Weigh 50 grams of sample and transfer to evaporating dish. Sludge samples are added by weight using pan balance.
5. Place evaporating dish with sample on steam bath and evaporate until hard.
6. Transfer dish to drying oven and dry at 103°C. for one hour.
7. Transfer dish to dessicator to cool.
8. Weigh dish with dry sample and record in step 9. Save this sample if volatile solids are to be determined.
9. Step 8 - Weight of dish and dry sample ______________________ g

   Step 3 - Weight of clean, dry dish - ______________________ g

   Weight of total solids - ______________________ g

   Compute results as follows:

   $$\frac{(\text{Wt of dish with dry solids} - \text{weight of dish}) \times 1{,}000{,}000}{\text{mL or grams of sample}} =$$

10. Record results: ______________________ mg/L total solids.

VOLATILE AND FIXED SOLIDS

Purpose of Test: To determine that portion of wastewater or sludge solids which is volatile, mostly organic material, and to determine that portion which is fixed, nondecomposable inorganic material

Method of Testing: Gravimetric following volatilization.

Principles of Test:

1. Total solids are first determined by evaporation of water and weighing the residue. See total solids test.
2. The organic or volatile solids are burned off in a muffle furnace at 550°C. At this temperature the inorganic material will not burn.
3. The weight of total solids, volatile solids, and fixed solids are determined as follows:
   a. Weight of evaporating dish with dried sample - weight of evaporating dish = weight of total solids.
   b. Weight of evaporating dish with dried solids - weight of dish and ash after burning = weight of volatile solids.
   c. Weight of dish and ash - weight of dish = weight of fixed solids.
4. Weight of each type of solid is converted to mg/L by the formula:

$$\frac{\text{Wt of solid X 1,000,000}}{\text{mL or grams of sample}} = \_\_\_\_\_\_\_\_ \text{ mg/L}$$

Equipment:

1. All equipment needed for total solids test
2. Muffle furnace
3. Heat resistant gloves
4. Tongs

Reagents: None

Procedure:

1. Determine the total solids for a sample (see total solids test).
2. Place evaporating dish with total solids residue in a muffle furnace at 550°C. and leave for approximately 15 minutes.
3. Remove dish from furnace and place in drying oven to cool for 10 minutes.
4. Remove dish from drying oven and place in dessicator to cool for 15 minutes.
5. Weigh dish with fixed solids on analytical balance and record the weight.
   a. Weight of dish and fixed solids ____________________ g
      Weight of dish (from Total Solids Test) - ____________________ g
      Weight of fixed solids ____________________ g

b. Weight of Total Solids
(from Total Solids Test) ______________________ g

Weight of Fixed Solids (Calculated Above) - ______________________ g

Weight of Volatile Solids ______________________ g

6. Compute results as indicated under principle 4 and record results as follows:

Volatile solids = ______________________ mg/L

Fixed solids = ______________________ mg/L

SPECIFIC CONDUCTANCE

Purpose of Test: To measure the specific conductance of a water sample as a relative measure of the dissolved ionizable solids as NaCl equivalent.

Method of Testing: Electric Conductance Meter

Principles of Test

1. Water without any dissolved solids is a very poor conductor of electricity.
2. Water which contains dissolved ionizable solids will conduct electricity in approximate proportion of the concentration of the ions.
3. A conductivity meter is used to measure the micromhos conductivity.

Equipment:

1. Solo-bridge (specific conductance meter)
2. Proper conductivity cell probes as follows:
    a. Low range probes for distilled or demineralized water samples.
    b. High range probes for raw or treated water samples.
3. Two, footed cylinders (beakers may be used if sufficiently deep enough to allow submergence of air vent on probes)
4. Conversion chart.

Procedure:

1. Fill container two thirds full of sample.
2. Select probes with high or low range depending on sample.
3. Rinse the probes in one of the cylinders of sample.
4. Place probes in second cylinder.
5. Plug in the meter and turn switch to "ON" position.
6. Check temperature of sample used to rinse probes.
7. Set temperature control on meter to temperature obtained in step 6.
8. Jiggle the probes in sample until all of the air bubbles escape through the vent holes. Keep probes submerged below vent hole level.
9. Turn the conductivity scale knob until the dark area of the eye or null indicator is at its widest size.
10. Read the meter and record the micromhos specific conductance of sample.

    NOTE: If high range probes are used, the meter reading must be multiplied by 10.
11. Turn switch to the off position and unplug the meter.
12. Rinse the probes in distilled water and store.
13. Use the conversion chart that is furnished with the meter to convert specific conductance to mg/L equivalent.
14. Record results:

    ________________________ Micromhos specific conductance.

    ________________________ mg/L NaCl equivalent.

SPECIFIC CONDUCTIVITY CONVERSION TABLE - TEMP. 78°F (25°C)

HIGH RANGE 500-20, 000 MICROMHOS/CM

MICRO MHO/CM	TOTAL DISSOLVED mg/L	SOLIDS GPM		MICRO MHO/CM	TOTAL DISSOLVED mg/L	SOLIDS GPM
500	239	14.0	:	2600	1320	77.1
550	264	15.4	:	2800	1420	82.9
600	298	17.4	:	3000	1525	89.1
650	315	18.4	:	3200	1625	94.9
700	341	19.9	:	3400	1740	102.0
750	366	21.4	:	3600	1845	108.0
800	391	22.8	:	3800	1960	114.0
850	417	24.4	:	4000	2065	121.0
900	445	25.0	:	4200	2180	127.0
950	470	28.2	:	4400	2280	133.0
1000	530	29.4	:	4600	2370	138.0
1050	523	30.5	:	4800	2460	144.0
1100	550	32.1	:	5000	2650	155.0
1150	576	33.6	:	5500	2900	169.0
1200	602	35.2	:	6000	3200	181.0
1250	627	36.6	:	6500	3475	203.0
1300	655	38.2	:	7000	3750	219.0
1350	805	39.6	:	7500	3970	232.0
1400	700	40.9	:	8000	4300	251.0
1450	720	42.0	:	8500	4575	267.0
1500	745	43.5	:	9000	4850	283.0
1600	800	46.7	:	9500	5130	300.0
1700	845	49.6	:	10000	5430	317.0
1800	900	52.5	:	12000	6700	391.0
1900	945	55.2	:	14000	7800	455.0
2000	1000	58.4	:	16000	9000	526.0
2200	1100	64.2	:	18000	10000	585.0
2400	1240	72.4	:	20000	11500	672.0

SPECIFIC CONDUCTIVITY CONVERSION TABLE - TEMP. 78°F (25°C)

LOW RANGE 0.0 - 500 MICROMHOS/CM

MICRO	TOTAL DISSOLVED SOLIDS		MICRO	TOTAL DISSOLVED SOLIDS	
MHO/CM	mg/L	GPM	MHO/CM	mg/L	GPM
0.0	0.0	0.0	46.0	21.7	1.3
1.0	0.3	0.02	48.0	22.7	1.3
2.0	0.6	0.04	50.0	23.6	1.4
3.0	0.9	0.05	55.0	26.0	1.5
4.0	1.5	0.09	60.0	28.5	1.7
5.0	2.0	0.12	65.0	30.8	1.8
6.0	2.5	0.14	70.0	33.1	1.9
7.0	3.0	0.17	75.0	35.4	2.1
8.0	3.5	0.21	80.0	37.7	2.2
9.0	4.0	0.23	85.0	40.1	2.3
10.0	4.5	0.25	90.0	42.5	2.5
11.0	5.0	0.29	95.0	45.1	2.6
12.0	5.5	0.32	100.0	47.7	2.8
13.0	6.0	0.35	110.0	52.0	3.0
14.0	6.5	0.38	120.0	56.7	3.5
15.0	7.0	0.41	130.0	61.4	3.6
16.0	7.5	0.44	140.0	66.0	3.8
17.0	8.0	0.47	150.0	70.8	4.1
18.0	8.5	0.50	160.0	75.5	4.3
19.0	9.0	0.52	170.0	80.2	4.7
20.0	9.5	0.55	180.0	85.0	5.0
22.0	10.5	0.60	190.0	89.7	5.2
24.0	11.3	0.66	200.0	95.0	5.6
26.0	12.3	0.72	220.0	105.0	6.1
28.0	13.3	0.78	240.0	113.0	6.6
30.0	14.2	0.83	260.0	124.0	7.2
32.0	15.1	0.88	280.0	133.0	7.8
34.0	16.0	0.95	300.0	143.0	8.4
36.0	17.1	1.0	350.0	167.0	9.8
38.0	17.9	1.0	400.0	200.0	11.7
40.0	19.0	1.1	450.0	214.0	12.5
42.0	19.9	1.2	500.0	239.0	14.0
44.0	20.9	1.2			

NOTICE: THE TOTAL DISSOLVED SOLIDS ARE IN TERMS OF SODIUM CHLORIDE

TEMPERATURE

Purpose of Test: To determine the temperature of water using both the Celsius and Fahrenheit scales.

Method of Testing: Mercury Thermometer.

Principles of Test:

1. All bodies of matter have the capacity to transfer heat energy by radiation, conductive and convection to a body of lower heat level or to absorb heat from a body of higher heat level until both bodies reach the same temperature.

2. In the mercury thermometer, heat is transferred from the sample to the mercury.

3. As the temperature of the mercury changes, its volume changes. An increase in the temperature expands the mercury and causes it to rise in the tube. A decrease in temperature causes the mercury to contract and lower its level.

4. On the Celsius scale thermometer, the mercury level point, at which water freezes is marked 0° and the point at which water boils is marked 100° with graduations between, above, and below these points being 1/100 of the difference between 0° and 100° mark.

5. On the Fahrenheit scale thermometer, the freezing point is marked 32° and the boiling point is marked 212°. The graduations are 1/180 of the distance between these points.

x. The temperature in one scale can be converted to the temperature on the other scale using the following formulas:

$$(1.8 \times {}^\circ C) + 32 = {}^\circ F \qquad \frac{{}^\circ F - 32}{1.8} = {}^\circ C$$

Equipment:

1. Mercury thermometer
2. 500 mL beaker

Reagents: None

Procedure:

CAUTION: The thermometer is easily broken by careless handling or by being exposed to heat greater than that for which it is designed. The mercury is also toxic if it gets into open cuts or is swallowed.

1. Fill beaker three fourths full of sample.

2. Place the thermometer, mercury end down, in the beaker and allow it to lie against the side of the beaker.

3. Wait three minutes and read the thermometer at the mercury level.

   NOTE: It is best to read the thermometer without removing it from the beaker. If you do remove the thermometer to read it, do not touch the mercury-filled end.

4. Leave thermometer in beaker and re-read at one minute intervals until the last two readings are the same.

5. Record the reading as ________ degrees _________ scale (scale, thermometer used).

6. Convert the reading to the other scale and record as:

   _____________ degrees ___________ scale (alternate scale.)

PROCEDURES FOR VOLUMETRIC TITRATION

Purpose of Exercise: To develop skills and techniques used in measuring impurities in water samples and in standardizing reagents by volumetric titrations.

Principles of Volumetric Titrations:

1. A reagent of known concentration, which will react with the impurity in the sample being tested, is added to the sample until one drop of excess reagent produces an observable reaction or change which indicates that all of the impurity has entered into the reaction. This observable reaction or change is known as the end point of the titration.

2. The end point may be indicated by one of the following changes:

   a. A change in color of an added organic dye, usually due to a change in pH.

   b. A change in pH as measured by a pH meter.

   c. A change in oxidation reduction potential, measured by an electrical potentiometer.

   d. A color change produced by an element, ion, or compound formed or removed at the completion of the reaction.

3. After the amount of reagent used is determined, the amount of the impurity in the sample is computed by one of the following methods:

   a. The mL of reagent x factor for given test = mg/L unknown constituent.

   b. $\frac{\text{mL. R} \times \text{NR} \times \text{Milli Eq. Wt.} \times 1{,}000{,}000}{\text{mL of sample}}$ = mg/L of constituent.

   Where

   R = Reagent
   N = Normality of Reagent
   Millequivalent wt is of the chemical form in which the unknown is expressed.

4. The Normality of a reagent being standardized may be computed using the formula:

   mL Reagent_1 X Normality Reagent_1 = mL Reagent_2 X Normality Reagent_2

   NOTE: Free mineral acid test is used for this exercise since it is representative of the various titration techniques.

Equipment:

1. Automatic buret assembly complete with buret, reagent bottle, two hole rubber stopper, rubber pressure bulb and tube.

   NOTE: Squeeze bottle, straight buret or pipets may be used with slight modification in step-by-step procedures.

2. Erlenmeyer flask (Casserole and glass stirring rod may be used for some tests).

3. Graduated cylinder.

Reagents:

1. Standard solution - 0.02N NaOH
2. End point indicator - Methyl orange

Procedures:

1. Fill buret bottle with standard reagent (0.02N sodium hydroxide).

   NOTE: This step will be performed by, or under the direction of the instructor.

2. Check stopcock for free movement. It should turn easily using two fingers and applying slight pressure. Do not push down on the stopcock as this will cause it to freeze. Do not pull up on it to turn it as this will allow reagent to be lost. If the stopcock does not turn easily, lubricate it as follows:

   a. Remove the small washer on bottom of the stopcock and remove it from buret.

   b. Apply a small film of lubricant above and below the small hole in the stopcock. Do not apply lubricant where it can get in the hole.

   c. Replace stopcock and washer and check to see if the hole is clear. Note position of stopcock when closed, open and partially open.

3. Close stopcock, place a finger over the small hole in the glass filling tube and press the bulb slowly to fill the buret with sufficient reagent to rinse the walls of the buret.

   CAUTION: Do not press bulb too hard; it will cause spillage of reagent.

4. Drain the reagent from buret, refill part way, and drain enough to remove air from the buret tip.

5. Fill buret slowly until it overflows back into the bottle.

6. Read the buret, at the point of reagent level. It should read 0 mL.

   NOTE: Each number on the buret represents 1 mL; each mark between numbers represents .1 mL. Liquids will not stand with a flat surface in the buret but will form a slight dish shape called the meniscus. The bottom of the meniscus is used to determine the level of liquid. Make sure the level is read with your eye in the same horizontal plane as the graduation being read.

7. Measure 50 mL of sample with graduated cylinder and pour into the Erlenmeyer flask.

8. Place flask under the buret tip and add reagent slowly (rapid drops). Rotate flask gently so contents will mix. When reagent causes a temporary color change as it strikes sample, slow the addition of reagent to a drop at a time until the end point is reached (sample turns straw yellow).

9. Read the buret at the liquid level and record mL reagent used.

10. Compute the mg/L impurity (FMA as $CaCO_3$) using a factor (20) as shown in principle 3a.

11. Compute the mg/L impurity (FMA as $CaCO_3$) as shown in 3b. Use .050 as milliequivalent wt of $CaCO_3$.

12. Record results.

    NOTE: Results are not recorded correctly unless correct unit of measures is shown.

13. If equipment is to be stored, drain reagent from buret and rinse with distilled water.

TURBIDITY (Nephelometric Method)

Purpose of Test: Turbidity is the muddy or unclear condition of water. It is caused by the fine suspended or collodial particles which do not settle readily.

Examples: silt, clay, and algae. The turbidity is expressed in Nephelometer Turbidity Units (NTUs).

Principles of test

The Model 2100 Hach Turbidity Meter is a true Nephelometer which does not measure the light transmitted or absorbed by the impurities in the sample but measures the light which is 90° angle by the suspended particles.

Equipment and supplies

1. Hach turbidity meter with following components as described below.
    a. Light shield - the long black tube which is placed over the cell (sample tube) well when reading the meter.
    b. Sample cells (4) - the glass tubes to hold sample.
    c. Turbidity standards (4) - Sealed glass tubes containing samples of know turbidity as marked (0.61, 10, 100, and 1000 NTUs) which are used to standardize the meter.
    d. Cell riser - A short black tube which must be placed in cell holder before using the 100 or 1000 range on the meter.
    e. Styrofoam plunger - Used to remove the cell riser from the cell holder.
    f. Focusing template - A black tube with white disk in the bottom which is used to check light focus. (Not used by student)
2. Graduated cylinder (25 mL)
3. Beaker for sample
4. Chem-wipe

Procedures

1. Prepare meter. The meter is normally left plugged in with the range selector knob on 100 and the light shield removed and door closed.
2. Clean cells - rinse cells with demineralized water and wipe outside with chem-wipe. If dirty they must be washed with soap and water and rinsed. The last amount of dust or finger marks will cause false reading.
3. Obtain sample in beaker and estimate turbidity as follows:
    a. Apparently clear as tap or demineralized water - 0 to 1 NTUs
    b. Very slight cloudiness or turbidity - 1 to 10 NTUs
    c. Slight greyish appearance - 10 to 100 NTUs
    d. Cloudy - 100 to 1000 NTUs

4. Standardize Meter

   a. Remove light shield.

   b. Select the lowest standard which would measure the estimated turbidity of the sample, wipe clean, and place in the cell holder.

   Note: lf the 100 or 1000 range is to be used the cell riser must first be placed in the cell holder.

   c. Place light shield over the cell holder.

   d. Turn range selector to the turbidity of the standard and adjust standardize control knob to make the needle on the scale read NTUs of the standard.

   e. Remove standard from cell holder.

5. Determining turbidity of sample.

   a. Add 25 mL of sample to clean sample cell, wipe, and place in cell well.

   b. Install light shield.

   c. Read proper scale and record as NUTs of sample.

6. Remove and clean cell. Leave meter in 100 range with light shield removed and door closed.

OPERATING INSTRUCTIONS FOR THE "METTLER H 30" ANALYTICAL BALANCE

1. Make sure the bubble on the top of the balance is centered.
2. Make sure that four zeros are visible on the indicating dial.
3. Plug in the electrical connection.
4. Make sure the red lock on the selector knob is fully extended. (1/8")
5. Zero the balance:
   a. Turn selector knob to "1" (Extreme Left)
   b. Turn the "0" control knob until six zeros are showing on the dial, and the center line is centered in the light slot of the index fork.
6. Return the selector knob to the zero position.
7. Place sample on pan. Close both doors.
8. Turn selector knob to the "1/2" position. (Extreme Right)
9. Turn the #10 control know slowly, in a clockwise direction, until the arrows on the filling guide suddenly reverse and point to the left.
10. Turn the #10 control knob back (counter clockwise) one click.
11. Turn the #1 control knob until the arrows on the filling guide suddenly reverse and point to the left, if it does not reverse, leave on 9 and continue to step #13.
12. Turn the #1 control knob back (counter clockwise) one click.
13. Return the selector knob to zero, then slowly place selector in #1 position.
14. Turn the digital counter control knob (on lower right side of balance) until next lower scale division is centered in the light slot of the index fork.
15. Read weight on indicating dial.
16. Return selector to zero position.
17. Turn control knobs until four zeros are on indicating dial.

OPERATING INSTRUCTIONS, MUFFLE FURNACE

Preoperation Procedures

1. Position the 208-volt circuit breaker to turn the power off.
2. Set the power selector switch and the "time cycle on" control knob (on the unit) to OFF position.
3. Check to see that the furnace is empty.

Operation Procedures

1. Observe the instructions and warnings on the metal plate attached to the unit.
2. Plug the unit into the 208-volt outlet.
3. Position the 208-volt circuit breaker in the ON position.
4. Set the power selector switch to medium.
5. Set the time cycle on control knob to 6 or higher number.

Shutdown Procedures

1. Position electrical control knob to 6 or higher number.
2. Position circuit breaker to OFF position.
3. Disconnect the unit from the electrical outlet.

STUDY GUIDES/WORKBOOK
J3ABR56631 000-III-1 thru 7

Technical Training

Environmental Support Specialist

WATER SUPPLIES AND TREATMENT

February 1986

3700 TECHNICAL TRAINING WING
3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

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ACKNOWLEDGEMENT

PREPARATION of Unit 5 of this SW was aided through the cooperation and courtesy of Ionigs Incorporated, Watertown, Ma. This company furnished the information concerning Electrodialysis Demineralization. Permission to use their publication, AQUAMITE 1, Operating and Maintenance Manual, Serial Number 527, is gratefully acknowledged. In accordance with the copyright agreement, distribution of this SW is limited to DOD personnel.

This supersedes Study Guide J3ABR56631 000-III, 1 thru 7, dated June 1984

3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

SW J3ABR56631 000-III-1

WATER WELL OPERATION AND MAINTENANCE

OBJECTIVES

Given incomplete statements about ground water and water wells, complete each statement by making written responses. Four of the six responses must be correct.

Using data pertaining to wells, define terms and calculate static, pumping, and drawdown levels with a maximum of one instructor assist.

INTRODUCTION

Any large group of people, such as found on an Air Force base, needs a sufficient supply of water. This supply may come from either surface water or ground water. In some areas lakes, streams, rivers, and ponds are used as a source of water. However, the Air Force prefers to use ground water when it is available in quantities large enough to satisfy water needs. Although the Air Force hires civilian contractors to drill and develop most wells, it is your job to operate and maintain them. In order to properly operate and maintain these wells, you should know the origin of ground water, methods used to explore for ground water, well construction techniques, and problems that may arise during the operation of wells. You must also determine the different water levels in a well in order to detect when it is running dry.

This study guide and workbook does not cover all of the information concerning wells. For more complete details, you should refer to AFR 85-23, Well Drilling Operations; and AFR 91-26, Maintenance and Operation of Water Supply, Treatment and Distribution Systems.

INFORMATION

THE ORIGIN OF GROUND WATER

Ground water is water which exists in a layer of rock or soil below the surface of the earth. This ground water, which is the source of water in wells, is supplied by a process known as the hydrologic cycle.

Hydrologic Cycle

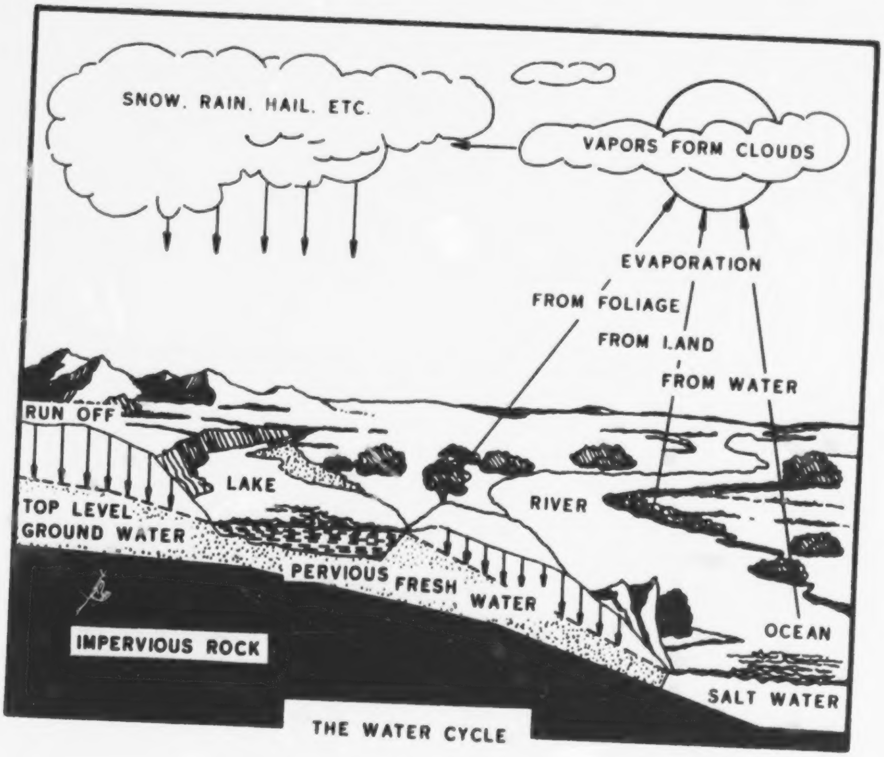
The hydrologic cycle is nature's way of reusing the limited supply of water by cycling it between the earth's surface and the atmoshpere. This recycling is necessary because no new water is formed. Water is purified and reused by nature as it goes through the steps of the hydrologic cycle. The steps of this water cycle, which are shown in figure 1-1, include evaporation, precipitation, runoff, infiltration and storage.

EVAPORATION: The conversion of water from streams, rivers, lakes, and ponds, (surface water) into a vapor is called evaporation. This water vapor rises to the atmosphere to form clouds.

PRECIPITATION: When the vapor in the clouds comes in contact with cooler air it condenses. The condensed vapor is heavier than air and so falls to the earth's surface as rain, sleet, hail, or snow (depending on the temperature of the air at the time). This is known as precipitation.

RUNOFF: As the precipitation falls to the earth's surface, some of it flows over the surface of the earth and forms streams, rivers, lakes, and ponds. Water flowing over the earth is called runoff.

INFILTRATION: Part of the water falling as rain, sleet, hail, and snow seeps through the ground. This process is known as infiltration.


SNOW. RAIN. HAIL. ETC.
VAPORS FORM CLOUDS
EVAPORATION
FROM FOLIAGE
FROM LAND
FROM WATER
RUN OFF
LAKE
RIVER
TOP LEVEL GROUND WATER
PERVIOUS FRESH WATER
IMPERVIOUS ROCK
OCEAN
SALT WATER
THE WATER CYCLE

CN-084

Figure 1-1. The Hydrologic Cycle

STORAGE: The water which filters through the rocks and soil is collected and stored in certain types of rock layers as ground water. This storage of ground water is the source of water in wells.

The layers of rock and soil which collect and store ground water are called aquifers.

Aquifers

An aquifer is a layer of rock or soil (stratum) which contains water. There are two types of aquifers--confined and unconfined (see figure 1-2).

CONFINED AQUIFER: A confined aquifer is a water-bearing stratum which has layers of rock or soil that do not allow pass through them (impermeable layers) both above and below. These impermeable layers are sometimes referred to as confining layers.

UNCONFINED AQUIFER: An unconfined aquifer is bound by an impermeable stratum below, but has a permeable layer of rock or soil that allows water to pass through above it. There are some areas in which water rises through this permeable layer to the surface of the earth and forms swamps, ponds, and lakes. The highest point to which the ground water rises is known as the water table.

Because this ground water is below the surface of the earth, it is not directly visible; therefore, you must use other methods to determine its presence.

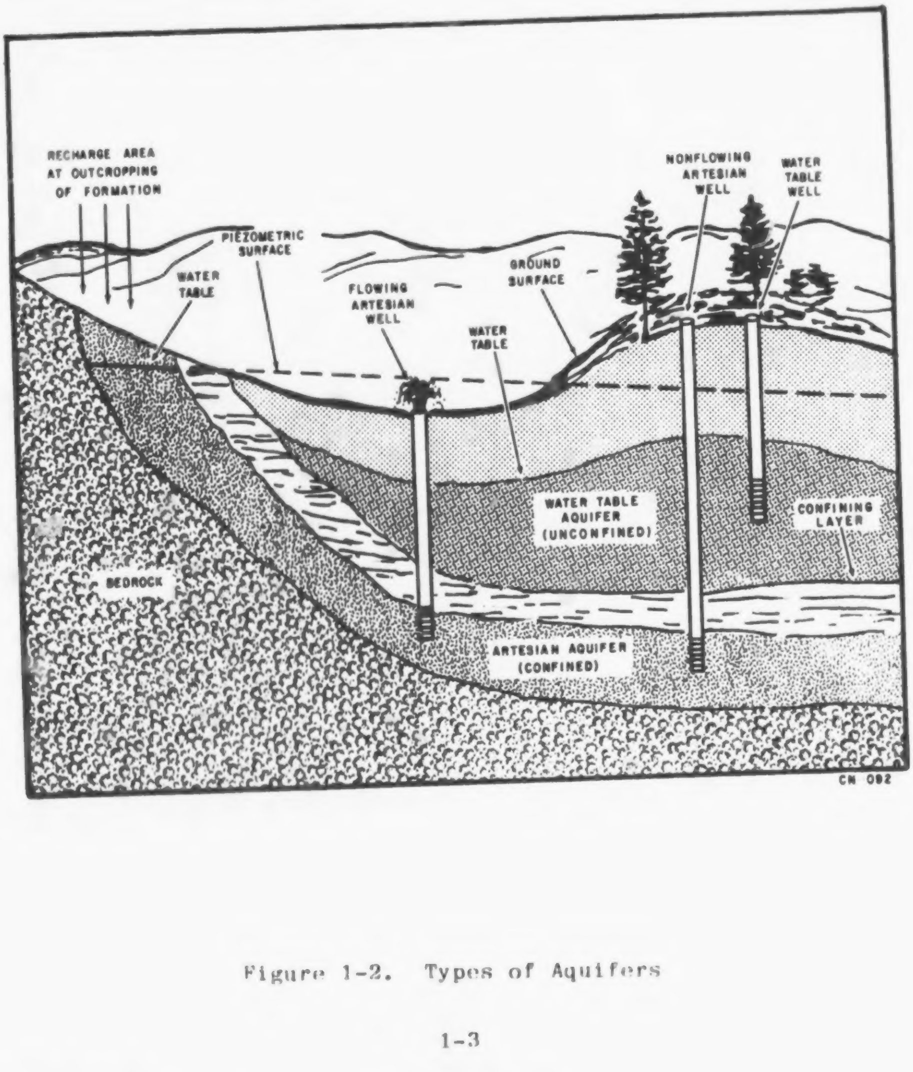

RECHARGE AREA AT OUTCROPPING OF FORMATION
PIEZOMETRIC SURFACE
WATER TABLE
FLOWING ARTESIAN WELL
GROUND SURFACE
WATER TABLE
NONFLOWING ARTESIAN WELL
WATER TABLE WELL
WATER TABLE AQUIFER (UNCONFINED)
CONFINING LAYER
BEDROCK
ARTESIAN AQUIFER (CONFINED)
CN 082

Figure 1-2. Types of Aquifers

EXPLORATION FOR GROUND WATER

There are several methods you can use to determine the presence of ground water. Some of the methods used are searching for existing wells and looking for the presence of springs, lakes and swamps. Determining the type and abundance of vegetation growing in an area, geophysical methods, and digging test wells may also be used.

Existing Wells

Searching for wells that have already been drilled in an area is one of the most reliable methods used to determine the presence of ground water. It not only confirms that ground water is present in an area, but it also yields information on the type of aquifer (whether it is confined or unconfined), the depth of the aquifer, and what method of well construction was used successfully in the area. There are, however, disadvantages to using this method of determining the presence of ground water. The biggest disadvantage to this method is that it can only be used in populated areas. You must use extreme care when you use water from already existing wells for military purposes. The well may have been abandoned due to contamination. Contamination may have been a result of accidental or natural causes (such as unintentional pollution from local waste disposal or animals) or deliberate poisoning by enemy personnel.

Springs, Lakes, and Swamps

Springs are points at which ground water flows to the surface of the earth. The presence of one or more springs is a good indication that at least some amount of ground water exists in an area. Lakes and swamps, on the other hand, indicate that ground water is present only if they are a result of a high water table. It is hard to determine if any particular lake or swamp is caused by ground water or collection of surface water.

Vegetation

In a dry region the type and abundance of plant growth can be used as an index to the location and depth of ground water. Success of finding water using this method depends on a knowledge of plants and their growth habits.

Geophysical Methods

The presence and depth of ground water may be determined using geophysical methods. The use of these techniques and instruments is very complex and in most cases requires equipment and skills not found in military engineering units. These methods would seldom be feasible for military needs.

Test Wells

The best method used to determine the existence of ground water in an area is to drill a well or test hole. The techniques described previously all give indirect information as to the presence and depth of ground water. Drilling a well or test hole gives you this information directly. The presence of ground water is indicated by the types of cuttings obtained while drilling. The amount of water present in the aquifer can be determined by running a pump test.

After the presence of ground water is found in quantities large enough to satisfy water needs, the well is drilled and developed.

WELL CONSTRUCTION

Wells are holes or shafts sunk into the ground for the purpose of obtaining water. The kind of well and the method used to construct the hole depend on such factors as the type of soil, quantity of water needed, and the depth of the aquifer. The methods used to construct the hole and the components which are found in a well are described below.

Hole Construction Techniques

In most parts of the world fresh water can be found by digging or drilling into the ground. In some areas shallow holes of only a few feet will find water, while in other areas it is necessary to drill through several hundred feet of rock and soil to find a source of water. Shallow dug wells are not normally used for military water supplies due to the difficulty of maintaining the structural and sanitary conditions of these wells. For the purpose of this lesson, the deep source of water supplies will be our main concern.

A large variety of methods and equipment are available for excavating holes in the earth for wells. The most important factor governing the method used is the occurrence of ground water in an area. It would be useless to use equipment with the ability to drill 100 feet in an area where the groundwater lies at a depth of 500 feet. It would also be a waste of time and money to try to drill a well in an area where the aquifer is hard rock with equipment capable of drilling through loose material. The methods of construction used by the military are down-hole percussion, rotary drilling, boring, driving, jetting, and digging.

DOWN-HOLE PERCUSSION: This method of drilling a well consists of alternately lifting and dropping a percussion drill (sometimes called a cable tool). This percussion drill is made up of a heavy bit and drill stem. The impact of the bit breaks up and loosens the rock material in the hole. Water is added to the hole to aid the drilling process. The loosened material, known as drill cuttings, is removed from the hole with a bailer. The bailer consists of a large tube or bucket with a hinged door or flap at the bottom end. When the bailer is dropped into the hole, it fills with the drill cuttings mixed with water. The door or flap prevents the bailer from emptying until it reaches the surface. Although this method of drilling wells is efficient, it is no longer in great use because of the time required to drill a deep well. The down-hole percussion technique has been almost completely replaced with the rotary method of drilling a well.

ROTARY TECHNIQUE: Rotary drilling uses a drill bit attached to a pipe. The bit cuts and breaks up the rock or soil material as it penetrates the formation. A drilling fluid, usually mud mixed with water, is pumped through the rotary drill pipe and flows from holes in the bit. This fluid swirls in the bottom of the hole and picks up the drill cuttings. It then flows upward in the space outside the drill pipe. This keeps the hole clean by carrying the cuttings from the hole to the earth's surface. The drilling fluid is circulated between the hole and settling pits.

The rotary method of drilling is much faster than the percussion drill and has another advantage of sealing the wall of the hole as it drills into the soil. The drill forces mud into the pore spaces of the hole wall, thus preventing the hole from caving in.

Although the Air Force uses the rotary method of drilling a well most often, there may be times when using another technique is more advantageous. Some of the other techniques are boring, driving, jetting and digging.

BORED WELLS: Boring is commonly done by using an earth auger. This auger may be either turned by hand or power-driven. Boring is practical in areas where ground water is found near the surface and when only small amounts of water are needed. You can use augers in materials in which holes 25 to 50 feet deep and 2 to 32 inches in diameter will not cave in.

DRIVEN WELLS: Wells with small diameters may be constructed by using a drive point. This drive point consists of a perforated pipe with a steel point at its lower end to break through pebbles or thin layers of hard rock material. The drive point must be driven deep enough to penetrate an aquifer below the water table, usually not more than 25 feet. The chief use of driven wells in military operations is for emergency well construction where the water table lies close to the ground surface.

JETTED WELLS: In this method a hole is drilled by using a large pipe with a small hole in the tip. A high pressure stream of water is pumped through the hole. The force of this stream of water loosens the material it strikes and washes the fine particles upward out of the well. As the fine particles are washed out of the hole, the pipe sinks. This method of well construction is particularly useful in sandy soils where the water table lies close to the surface of the ground.

DUG WELLS: Most dug wells are circular in shape, since a circular hole does not tend to collapse. Digging is the oldest method used to construct a well. Before modern tools and equipment were invented and used for well construction, it was common practice to dig a hole in the earth down to the water table for use as a well. Dug wells are lined or curbed with wooden staves, concrete, or metal curbing to prevent it from collapsing.

After the hole is drilled or dug, the other components are installed in the well.

Well Components

Well components will be covered in the following order: hole, casing, screen, base plate, gravel pack, and pump assembly. Figure 1-3 will show you these components and their relation to one another.

HOLE. Access to ground water is through a hole or shaft. Hole sizes vary widely in both diameter and depth. The diameter of a well may vary from less than 2 inches to more than 10 feet. Depths range from less than 10 feet to more than 7,000 feet; however, the 7,000 feet depth is close to the economic limits of using wells as a source of water. Care must be taken to prevent the wall of the hole from caving in and keeping surface water out.

CASING. The casing is used in a well to prevent the wall from collasping. This component also prevents surface drainage and polluted ground water from entering and contaminating the well. The straight casing is probably the most common type used. It consists of a large pipe or housing for the pump, and is installed at the time of drilling. This casing or pipe should extend from at least one foot above the surface of the ground to the last impermeable layer of rock or soil overlying the aquifer. The space between the outside of the casing and the inside of the hole must be tightly sealed with grouting (a fluid mixture of cement and water with the consistency of paste). Above the surface of the ground, on top of the casing and the inside of the hole must be tightly sealed with grouting (a fluid mixture of cement and water with the consistency of paste). Above the surface of the ground, on top of the casing, is a well head. This structure consists of a sanitary seal and concrete slab, usually sloping away from the well. The well head prevents surface water from entering the well.

SCREEN: Screens prevent large rock material from entering the pump during well operation, helps the casing prevent the hole from collapsing, and allows water to enter the well. The length of the screen is determined by the thickness of the aquifer. This component is normally made out of brass, bronze, or stainless steel. The drive-well point, continuous-slot (figure 1-4), the wire-wrapped pipe-base, and the brass tubular are the most common types of screens used. The sizes of the openings vary with each type of screen to fit the gradations of the water-bearing sand.

BASE PLATE: A base plate is installed in the bottom of the screen. It prevents sand from entering the well through the bottom of the screen.

GRAVEL PACK: There are some areas where the sand is so fine that the screen and base plate cannot prevent its entry into the well. In these areas, a gravel pack is installed to prevent these fine sand particles from entering the well. To place the gravel, you must construct a hole larger in diameter and use a double casing down to the aquifer. A space between the two casings is then made to receive the gravel (see figure 1-5 to see a gravel packed well). The gravel pack also acts as a reservoir as water from the aquifer fills the pore spaces between the gravel. This reduces the speed of the water entering the well. The slow-moving water does not erode the rock formation and does not carry as many suspended particles. As a result, clogging of the screen and the aquifer is slowed. This increases the amount of water delivered by the well. A gravel packed well costs more initially, but pays for itself with an increased water production over a longer period of time.

PUMP ASSEMBLY: A pump is used to lift the ground water to the surface. The selection of a pump for a well depends on such factors as the size of the well and the amount of water needed. Some pumps are installed above the ground and are called suction pumps. Those pumps that are lowered into the well casing are known as submerged or deep well pumps.

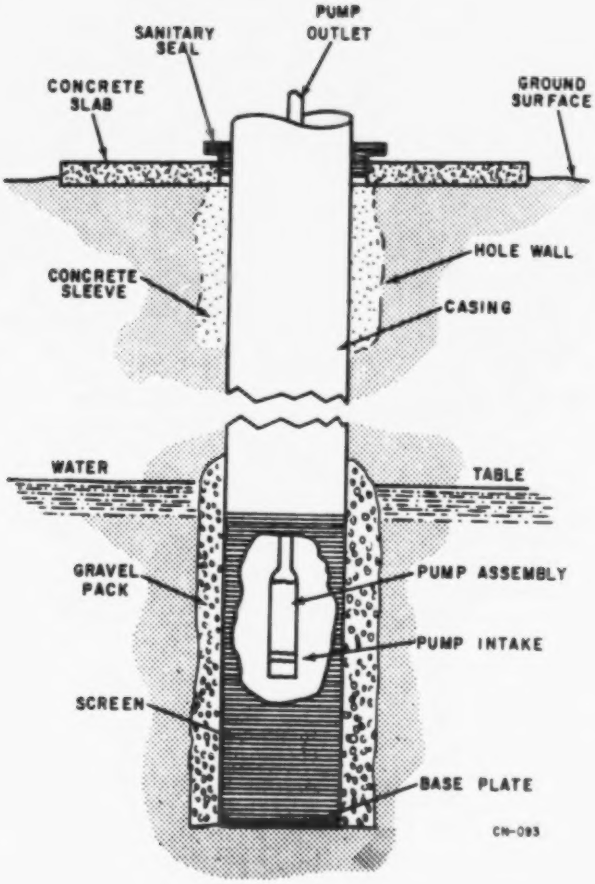

PUMP OUTLET
SANITARY SEAL
CONCRETE SLAB
GROUND SURFACE
HOLE WALL
CONCRETE SLEEVE
CASING
WATER
TABLE
GRAVEL PACK
PUMP ASSEMBLY
PUMP INTAKE
SCREEN
BASE PLATE
CN-093

Figure 1-3. Cross Section of a Typical Well

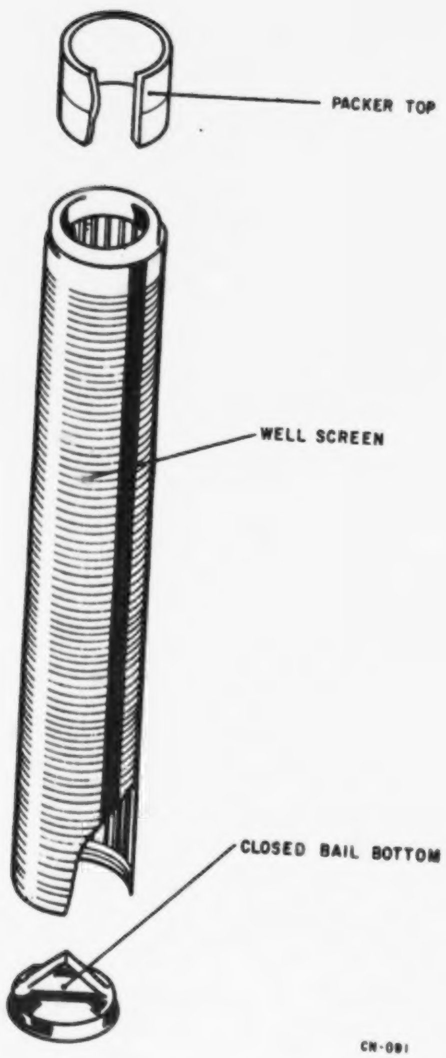

PACKER TOP
WELL SCREEN
CLOSED BAIL BOTTOM
CN-081

Figure 1-4. Continuous-Slot Well Screen

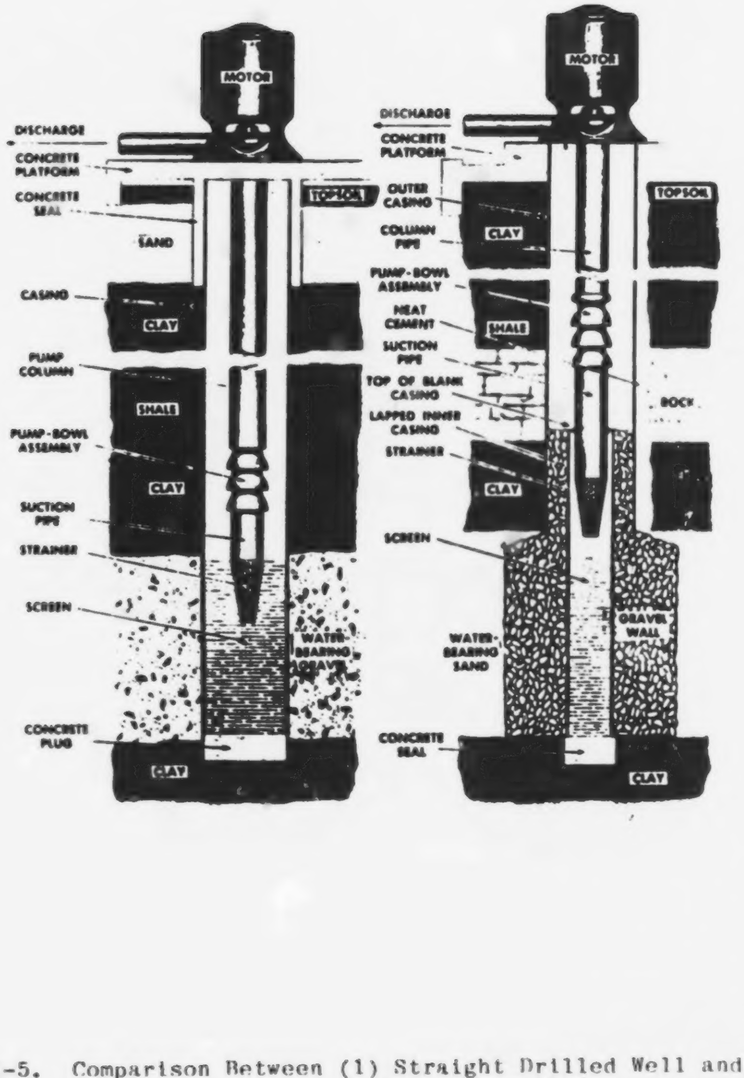

MOTOR
DISCHARGE
CONCRETE PLATFORM
CONCRETE SEAL
TOPSOIL
SAND
CASING
CLAY
PUMP COLUMN
SHALE
PUMP-BOWL ASSEMBLY
CLAY
SUCTION PIPE
STRAINER
SCREEN
WATER-BEARING GRAVEL
CONCRETE PLUG
CLAY
MOTOR
DISCHARGE
CONCRETE PLATFORM
OUTER CASING
TOPSOIL
CLAY
COLUMN PIPE
PUMP-BOWL ASSEMBLY
NEAT CEMENT
SHALE
SUCTION PIPE
TOP OF BLANK CASING
ROCK
LAPPED INNER CASING
STRAINER
CLAY
SCREEN
GRAVEL WALL
WATER-BEARING SAND
CONCRETE SEAL
CLAY

Figure 1-5. Comparison Between (1) Straight Drilled Well and (2) Underreamed Gravel Packed Well

After the well has been drilled, developed, and the pump assembly is installed, it becomes an integral part of the water supply and distribution system. Like any other piece of equipment, wells must be maintained on a regular basis.

WELL PROBLEMS AND MAINTENANCE

The problems which occur most often during the operation of wells are encrusted or corroded screens; clogged screens, gravel pack and pores of the surrounding rock formation; and cracked casings. You must not only conserve the ground water supply, but also protect it from contamination. The wells must be disinfected when necessary.

Well Screens

Ground water may contain minerals that cause hardness and acidity. Well screens are constantly exposed to these minerals when wells are operated every day. As a result, those minerals encrust and corrode the well screens. You must clean the screens periodically to prevent mineral scale buildup and corrosion from greatly reducing the amount of water produced. The methods used to clean well screens include chemically treating them with acids, chlorine, and phosphates. Dry ice and jet cleaning can also be used to remove scale and corrosion from the screens.

ACIDIZING: Treatment with inhibited muriatic or sulfamic acid cleans encrusted screens. Muriatic acid (27 percent concentration of hydrocholoric acid) is used most often to clean well screens. Sulfamic acid (not to be confused with sulfuric acid) may be used in place of muriatic acid. It does not attack the metal screens as rapidly as muriatic acid. The inhibitors added to both of these acids allow them to attack the mineral scale rather than the metal screens. The procedures for using these acids are found in AFR 91-26.

CAUTION: ACIDS CAUSE CHEMICAL BURNS. You should call an experienced, qualified contractor to clean well screens with acids. Do not use any wells near the well being treated with acid.

CHLORINE TREATMENT: In addition to muriatic or sulfamic acid, chlorine may be used to clean well screens. Chlorine removes bacterial slime growing on the well screens. When mixed with water, chlorine forms a weak acid which attacks mineral scale caused by hardness minerals. When using chlorine to clean well screens, use a solution containing 100 to 200 ppm of chlorine.

PHOSPHATE TREATMENT: Phosphates are used to prevent scale from forming on well screens. These chemicals keep the minerals in solution so that they do not settle on the screens and form scale deposits.

DRY ICE: Cleaning well screens using dry ice is simpler and safer than treating them with chemicals; however, this method may or may not work. Dry ice is frozen carbon dioxide (CO_2) gas. As the ice melts in the well, CO_2 gas is formed. This gas builds up pressure in the well, which forces water down the well and out through the screen at the bottom. The force of the water leaving the well into the aquifer dislodges scale.

CAUTION: Use extreme care when you use dry ice to clean the screens. Use tongs or wear heavy gloves when you add the chunks of dry ice into the well; dry ice may cause burns. Provide a means to control or release the CO_2 gas to prevent excessive buildup of pressure. Because CO_2 gas will suffocate you, provide ample ventilation, especially if the well is housed.

JET CLEANING: Jet cleaning of well screens uses a high velocity stream of water to dislodge scale from the screens. The equipment used to jet clean well screens include a jetting tool, a high pressure pump, 2-inch piping, and an ample supply of water. Lower the jetting tool into the well down to the screen and turn on the high pressure pump. Run the well pump to remove excess water and the dislodged material.

There may be times when the well screens are so badly encrusted and corroded that they cannot be cleaned using the methods mentioned in the previous paragraphs. In these cases the screens must be pulled and replaced. Repairing the screens in the field is not practical.

The amount of water delivered by wells is reduced not only by encrusted and corroded screens, but also by clogging of the screen, gravel pack and the pores of the formation.

Clogged Screen, Gravel Pack, and Pores of the Formation

The fine sand particles of some aquifers will eventually clog the screen and gravel pack of the well. This reduces the amount of water entering the well. Sand will also clog the pores of the aquifer surrounding the well, preventing water from entering the aquifer. You can unclog these structures by using one of the following methods: surging, backwashing and surging, or backwashing and backblowing.

SURGING: A well can be surged without pulling the pump from the well, and without expert help. The well is surged by turning the well pump on and off at intervals of 3 to 5 minutes. This operation raises the water in the well and allows it to fall again. The falling water flows out of the bottom of the well through the screen and gravel pack, and into the aquifer. As water flows out of the bottom of the well, it dislodges sand from the screen, gravel pack, and the pores of the formation around the well.

CAUTION: The falling water may cause the motor and impeller to turn in the reverse direction. Do not attempt to turn the pump on during this time.

BACKWASHING AND SURGING: When surging alone does not dislodge the sand, backwashing may be used. This procedure consists of forcing a large amount of water down the well. If bypass pump connections have not been installed, remove the flap from the check valve. Open the discharge valve to allow water from the storage tank to rush down the well casing. If the screen is badly clogged or the well is badly sanded or silted, the well will quickly fill and water will flow from the vent holes in the pump head. Allow the backwashing to continue for 5 minutes, then close the backwash valve. Open the pump discharge valve and start the pump. Run the discharge to waste until the water is clear.

CAUTION: Before starting the wash water, be sure the pump and motor turn freely. The down rush of water rotates the pump in the reverse direction and may unscrew the pump shafting.

BACKWASHING AND BACKBLOWING: A combination of backwashing with water and backblowing with compressed air may be used if the pump has been pulled. The compressed air increases the surging action of the wash water. It also acts as an air lift pump to remove the dislodged sand from the well. Because of the complex equipment used, you should call an experienced contractor to clean wells with this method.

Concrete casings are subject to cracking after years of use. This may allow contaminated ground water to enter the well. The joints between the concrete and the sanitary seal of the well head may separate, letting surface water flow into the well. You must pull and repair or replace the cracked casing, and repair the split joints of the well head.

One of the most important tasks you must perform when operating and maintaining wells is conserving the ground water supply.

Conservation of Ground Water

There is a limited supply of ground water. The only way nature can replenish this supply is through that step of the hydrologic cycle known as infiltration. You must make sure that pumping water from wells does not deplete the ground water supply. You can do this by balancing the operation of the pumps so that ground water is not taken from the wells at a rate faster than it is replenished. Balancing the pumping schedule also reduces wear and tear on the pumps.

There are some areas in which the ground water has been pumped at a rate faster than it has been replenished. In these areas, the process of artificially recharging the ground water has been developed. During this process storm water, stream flow, or treated wastewater is pumped or allowed to seep into the aquifer.

Not only must you conserve ground water, but you must also prevent its contamination.

Protection of Ground Water Supplies

Protection of the ground water supplies from contamination includes performing a sanitary survey; and protection against contamination from the surface, underground, and through improper operation.

SANITARY SURVEY: You must perform a sanitary survey twice a year to identify and correct any condition which may contaminate the wells. Contamination of the wells may come from surface water, cesspools, latrines, septic tanks and their drainage fields, sewer lines, and unsealed abandoned wells.

PROTECTION AGAINST SURFACE CONTAMINATION: To prevent surface water from entering and contaminating wells, locate them on high ground when possible. The wells should also be as far as possible from ponds, lagoons, barnyards, and outhouses (privies). If high ground for natural drainage is not available, grade the surface of the ground within 50 feet of the well so that water flows away from the well. Provide a fence to keep livestock at least 50 feet away from the well. The watertight slab of the well head must extend at least 18 inches beyond the casing to prevent surface water from flowing into the well.

PROTECTION AGAINST UNDERGROUND CONTAMINATION: To prevent contaminated ground water from entering a well, locate the well from latrines, septic tanks, subsurface drainage fields, and polluted bodies of water. The distance between the well and the possible source of contamination depends on local conditions such as the direction in which the ground water is flowing, the tightness of the soil, and the rate of pumping.

Although you have taken full protective measures to prevent contamination of wells, it is hard to detect all possible soures of pollution. Therefore, you must disinfect all sources of well water.

PROTECTION AGAINST CONTAMINATION THROUGH IMPROPER OPERATION. To guard against contamination through improper operation, prime the well pump with potable water (water that is safe to drink). Keep the drain from the base of the well pump open and free of obstructions so that any leakage flows away from the pump. Disinfect the well pump before you install it or after any repairs are made.

DISINFECTION OF WELLS

You must disinfect wells after they are initially installed, each time the screen is cleaned, each the pump is pulled, and when the well is contaminated.

PROCEDURES: To disinfect a well, first pump the water in the well to waste for several hours to remove as much of the pollution as possible. Then calculate the volume of water in the well to determine the amount of chlorine solution needed (two quarts of solution for every 100 gallons of water is recommended). The recommended dosage of chlorine to disinfect a well is 100 ppm. Stronger solutions may damage pump parts or the well screen. Pour the chlorine solution directly into the well through a clean hose. Connect a hose to the pump discharge and direct the flow of water back into the well. Operate the pump until you detect a strong chlorine odor. Allow the water to stand in the well for 24 hours. At the end of the 24-hour period, pump the water in the well to waste until the chlorine is reduced to an acceptable level. Obtain samples for bacteriological analysis before putting the well back into service. Refer to AFR 91-26 for further information on well disinfection.

EXERCISE III-1-1a

INSTRUCTIONS: Complete the following questions. You may consult your instructor if you have any questions.

1. What is an aquifer? ____________________

2. List the two types of aquifers.

   a.

   b.

3. List three methods used to explore for ground water.

   a.

   b.

   c.

4. List three techniques used to construct well holes.

   a.

   b.

   c.

5. Which method of well drilling has replaced the down-hole percussion technique?

   ____________________.

6. What is the purpose of the well casing? ____________________

7. What helps support the hole, keeps large rocks out, and allows the water to enter the well? ____________________

   ____

8. What is the purpose of gravel packing a well? ____________________

   ____

9. List three methods used to remove fine sand from the screen, gravel pack, and the pores of the formation.

   a.

   b.

   c.

10. What is the recommended dosage of chlorine for disinfecting a well? ____________

CALCULATE WELL LEVELS

You must conduct well tests to determine the capacity and performance of a well. These tests include measuring the static, pumping, and drawdown levels of water in a well. Knowing the definitions of static level, pumping level, drawdown, and other related terms will help you when you determine these water levels. You must also maintain current records related to the operation, maintenance, and testing of wells.

Definition of Terms

Water levels and drawdown measurements are necessary for an accurate determination of the capacity of a well and for its operation within safe limits. For a better understanding of static level, pumping level, drawdown and other related terms see the definitions below.

STATIC WATER LEVEL: The level of water in a well when the pump is at rest.

PUMPING LEVEL: The level of water in a well while the pump is operating.

DRAWDOWN: The is the distance the water level in a well drops due to pumping (Pumping Level - Static Level).

ZONE OF INFLUENCE: When water is pumped from a well, a depression is produced in the water table outside the well. This depression is called the zone of influence (see figure 1-6). Zones of influence of wells close together may overlap. If these wells are pumped at the same time, they will compete with each other for the ground water (see figure 1-6). As a result, each well produces less water than if it were operating by itself. Therefore, when a water supply is taken from a group of wells, those being pumped at any one time should be far enough apart so that the zones of influence do not overlap.

MAXIMUM YIELD: This is the maximum number of gallons per minute that can be pumped from a well over a six hour period. During this time the pumping rate is maintained so that the pumping level remains stationary. An increase in the pumping rate would cause the well to run dry.

DESIRED YIELD: This is the rate at which the well is expected to produce.

SAFE YIELD: This is the rate of pumping that produces a drawdown which is 50 per cent of the drawdown obtained when the well was built and pumped at maximum yield. Operating the well within its safe yield will prolong its productive life.

SPECIFIC CAPACITY: This is the number of gallons per minute pumped per foot of drawdown. The specific capacity is not the same for each foot of drawdown, but is approximately so when the drawdown is not too great. Knowing the specific capacity of a well enables you to estimate the drawdowns that will be produced at different pump settings.

Mathematical Formulas

Before you can measure the different water levels in a well, you must know the total length of the air line (also known as the telltale). It extends from the top of the well down to the base plate at the bottom to the well (see figure 1-7). You can find the length of the air line by referring to AF Form 996, Well Data Form. The telltale is usually a 1/4-inch pipe which is installed at the time the well is constructed. A bicycle tire pump and pressure gauge are attached to the end of the telltale at the ground surface. All joints must be airtight.

You must know how to convert the psi (pounds per square inch) on the pressure gauge to feet of water. One psi is equal to 2.31 feet. To convert the gauge psi to feet, multiply the pressure by 2.31 (feet of water = psi X 2.31).

STATIC LEVEL: This is the height to which the water in the well rises while the pump is at rest. Because water trends to seek its own level, it will rise in the air line up to the static level.

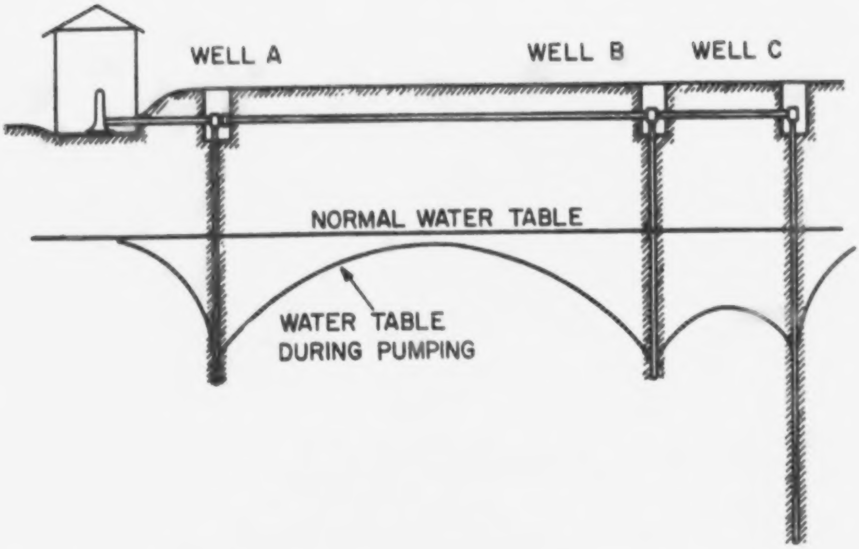

WELL A
WELL B
WELL C
NORMAL WATER TABLE
WATER TABLE
DURING PUMPING

Figure 1-6. Zone of Influence of Well Pumping on Water Table

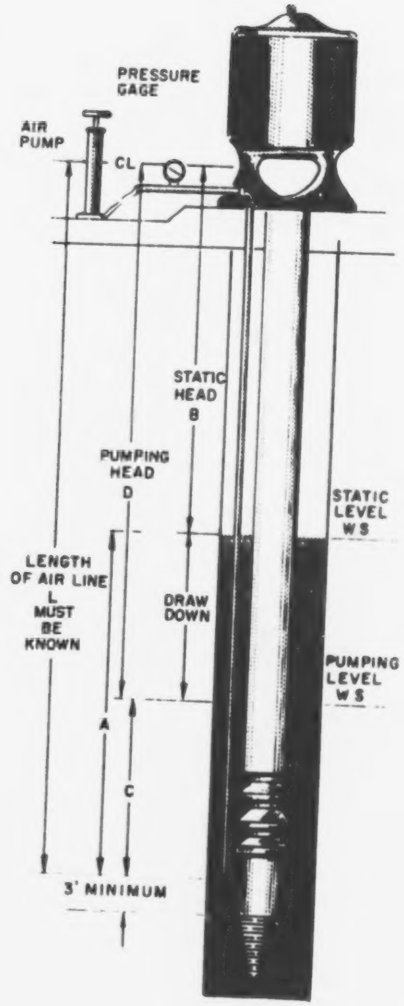

PRESSURE GAGE
AIR PUMP
CL
STATIC HEAD B
PUMPING HEAD D
STATIC LEVEL W S
LENGTH OF AIR LINE L MUST BE KNOWN
DRAW DOWN
PUMPING LEVEL W S
A
C
3' MINIMUM

Figure 1-7. Using Air line to Find Depth of Water Level

The static level is equal to the total length of the air line minus the psi before pumping (BP) times 2.31 [Static Level = Length of air line - (PSI BP X 2.31)]. With the pump shut down, apply air pressure through the bicycle tire pump until the needle on the pressure gauge no longer shows an increase in pressure. The reading on the pressure gauge shows the amount of air pressure needed to force the standing water out of the air line. Multiply the pressure in psi by 2.31. This determines the height of the water from the bottom of the telltale to top of the static level. Subtract the calculated height of water from the bottom of the air line from the total length of the telltale. This is the static level, which is measured from the top of the well down to the water level.

For example, assume the length of the air line is 150 feet. Assume that the pressure gauge reads 25 psi when air is applied to the air line. To find the static level of water in a well, multiply 25 psi by 2.31 (25 X 2.31 = 57.75 feet). Next subtract the height of the water from the bottom of the air line from the total length of the telltale (150 - 57.75 = 92.25 feet). The static level measured from the top of the well is 92.25 feet.

PUMPING LEVEL: This is the height at which water stands in the well while the pump is operating. Since the water level falls gradually when pumping begins, the pumping level is determined after the pump operates for at least one hour.

Pumping level is equal to the total length of the air line minus the psi while pumping (WP) times 2.31 [Pumping Level = Length of air line - (PSI WP X 2.31)]. When the well pump has been operating for at least one hour and the water level has stabilized, apply air pressure through the bicycle tire pump until the needle on the pressure gauge no longer shows an increase in pressure. Since the water level in the well is lowered by pumping, the amount of water in the air line is also lowered. Therefore, you will need less air pressure to force water out of the telltale. Multiply the pressure in psi by 2.31. This determines the height of water from the bottom of the air line to the pumping level. Subtract the calculated height of water from the total length of the air line. This gives you the pumping level of water in the well, which is determined from the top of the well down to the water level.

For example, assume the length of the air line is 150 feet. Assume the pressure gauge reads 18 psi. First you convert the psi to feet by multiplying the pressure by 2.31 (18 X 2.31 = 41.58 feet). Next you subtract the calculated height of water from the total length of the air line (150 - 41.58 = 108.42 feet). The pumping level, which is measured from the top of the well down to the water level, is 108.42 feet.

DRAWDOWN: Drawdown is the distance the water level in the well drops due to pumping. It can be determined by one of the following methods:

1. Pumping level minus static level. For example, 108.42 - 92.25 = 16.17 feet of drawdown.

2. Psi before pumping (BP) minus psi while pumping (WP) times 2.31 [(PSI BP - PSI WP) X 2.31]. For example, (25 - 18) X 2.31 = 7 X 2.31 = 16.17 feet of drawdown.

The static level, pumping level, and drawdown test results should be recorded on AF Form 997, Daily Well Activity Record.

Use of Records

You must keep logs and records current when you operate, maintain, and test wells. These records are very important, because they are the only way you can see what is happening at the bottom of the well. These records and logs should include such information as static and pumping water levels, drawdown, and gallons per minute pumped. They should also include the structural details of the well or wells.

Comparison of the data listed on these records and logs may help you anticipate and correct difficulties before they become serious. The following examples prove the value of properly maintained records:

1. A falling static level may indicate a gradual lowering water table.

2. An increased drawdown may show receding ground water level; interference from other wells; leaking casing or delivery pipes; encrusted or corroded well screens; or clogging of the screen, gravel pack, or pores of the rock formation.

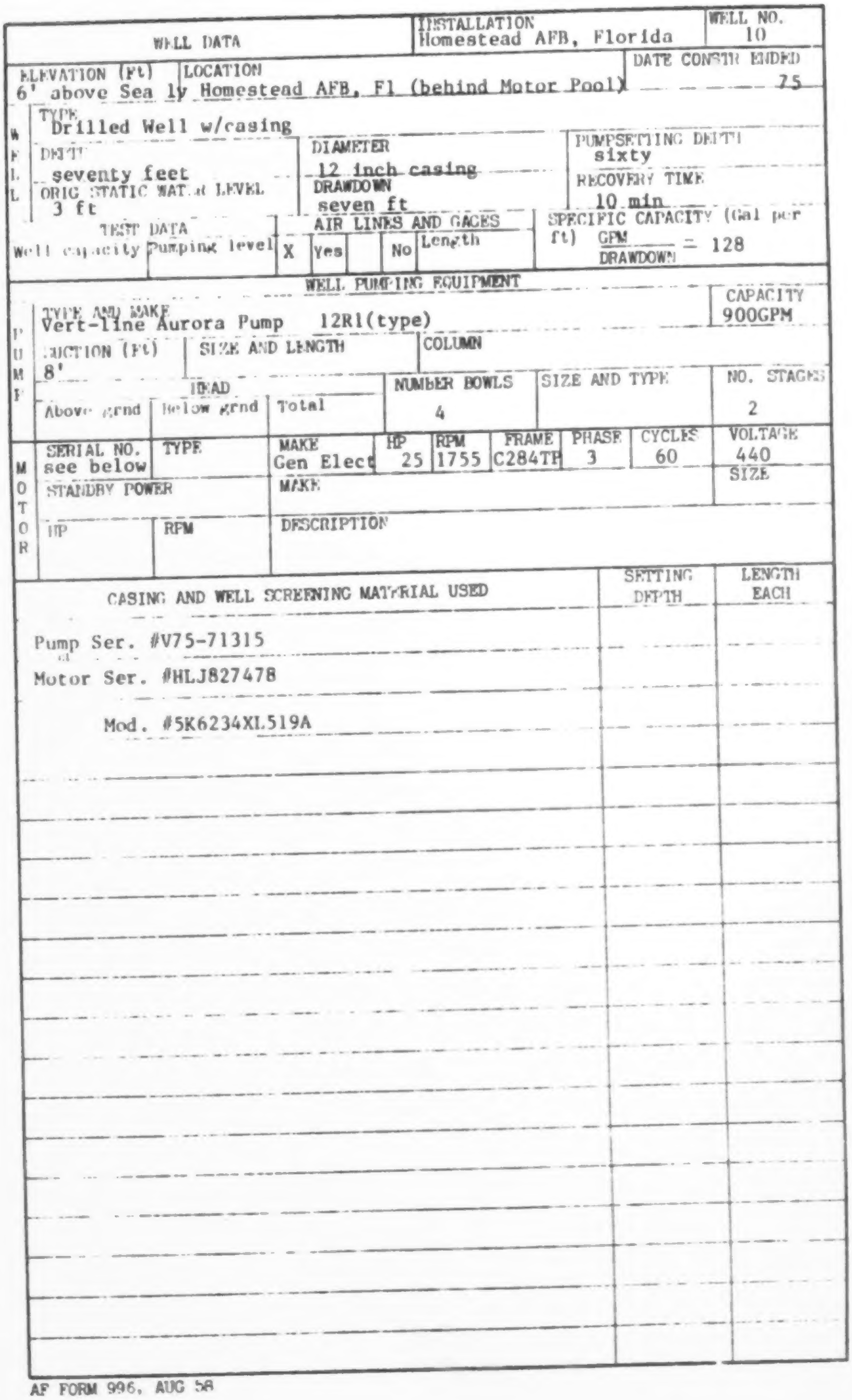
3. An increased drawdown when the static level remains the same is caused by encrusted or corroded screens, or clogged screen and gravel pack.

The records used for the operation, maintenance, and testing of wells are the well chart; AF Form 996, Well Data; and AF Form 997, Daily Well Activity Record.

WELL CHART: A well chart is a profile of the well and the rock formations surrounding the well. It is not necessarily drawn to scale. It shows the depths of the water levels, pump, and well screen. It also shows the length of the screen and the various types of earth layers. You can quickly see the operating conditions of the well by referring to the well chart.

AF FORM 996, WELL DATA: AF Form 996 is prepared for each well. It is completed when the well is built and is brought up to date whenever the well is tested. All well data forms are kept on file in a notebook. They are referred to when repairs are made on the well or when other wells are built in the same area. AF Form 996 is locally produced on 8" X 3" paper (see figure 1-8).

AF FORM 997, DAILY WELL ACTIVITY RECORD: This form is completed each day. It indicates which pumps are used and for what periods of time. It is used to equalize the use of wells and pumping equipment by alternating the periods of operation. AF Form 997 can also be used to detect changes in well characteristics and conditions. This form is useful when determining routine maintenance on equipment. The daily well activity record includes the names of shift operators, breakdowns, and other information related to the daily operation of wells. AF Form 997 is shown in figure 1-9.



WELL DATA	INSTALLATION Homestead AFB, Florida	WELL NO. 10
ELEVATION (Ft) 6' above Sea ly	LOCATION Homestead AFB, Fl (behind Motor Pool)	DATE CONSTR ENDED 75

W E L L

TYPE: Drilled Well w/casing

DEPTH seventy feet	DIAMETER 12 inch casing	PUMPSETTING DEPTH sixty
ORIG STATIC WATER LEVEL 3 ft	DRAWDOWN seven ft	RECOVERY TIME 10 min

TEST DATA		AIR LINES AND GAGES					SPECIFIC CAPACITY (Gal per ft)
Well capacity	Pumping level	X	Yes		No	Length	GPM / DRAWDOWN = 128

WELL PUMPING EQUIPMENT

P U M P

TYPE AND MAKE Vert-line Aurora Pump 12R1(type)			CAPACITY 900GPM
SUCTION (Ft) 8'	SIZE AND LENGTH	COLUMN	

HEAD			NUMBER BOWLS	SIZE AND TYPE	NO. STAGES
Above grnd	Below grnd	Total	4		2

M O T O R

SERIAL NO.	TYPE	MAKE	HP	RPM	FRAME	PHASE	CYCLES	VOLTAGE
see below		Gen Elect	25	1755	C284TP	3	60	440

STANDBY POWER			
		MAKE	SIZE
HP	RPM	DESCRIPTION	

CASING AND WELL SCREENING MATERIAL USED	SETTING DEPTH	LENGTH EACH
Pump Ser. #V75-71315		
Motor Ser. #HLJ827478		
Mod. #5K6234XL519A		

AF FORM 996, AUG 58

Figure 1-8. AF Form 996

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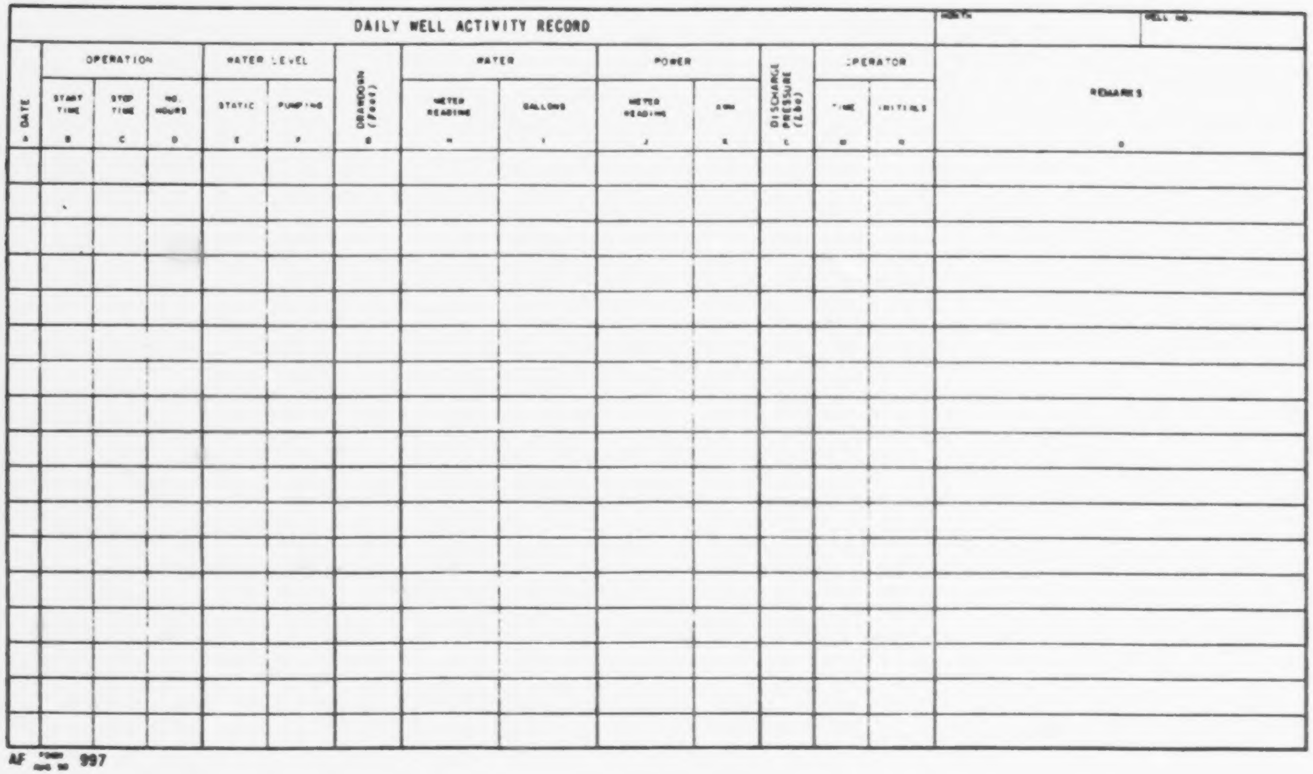

DAILY WELL ACTIVITY RECORD

MONTH

WELL NO.

DATE	OPERATION			WATER LEVEL		DRAWDOWN (Feet)	WATER		POWER		DISCHARGE PRESSURE (Lbs)	OPERATOR		REMARKS
	START TIME	STOP TIME	NO. HOURS	STATIC	PUMPING		METER READING	GALLONS	METER READING	KWH		TIME	INITIALS	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O

AF FORM AUG 90 997

Figure 1-9. AF Form 997

EXERCISE III-1-1b

PART I

INSTRUCTIONS: Complete the following questions. You may consult your instructor if you have any questions.

1. Define static level. ____
____.

2. Define pumping level. ____
____.

3. Define drawdown. ____
____.

4. How many feet of water equal one psi? ______________________________.

5. Calculate the static level of a well when the air line is 700 feet long and the psi before pumping is 21. ____
____.

6. List two methods you can use to determine the drawdown of a well.
   a.
   b.

7. Determine the drawdown of a well when the psi before pumping is 20 and the psi while pumping is 15. ____
____.

8. Determine the static level, pumping level, and drawdown of a well when the air line is 400 feet long, the psi before pumping is 40 and the psi while pumping is 25.
____
____.

PART 2

INSTRUCTIONS: Use the procedures below to operate the well trainer and to calculate static level, pumping level, and drawdown.

OPERATING INSTRUCTIONS FOR THE WELL TRAINER

SAFETY PRECAUTIONS

1. Remove all jewelry before operating the trainer.
2. Make sure that the power cable is connected to an outlet with a third ground wire.

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PRELIMINARY ADJUSTMENT:

Before attempting to operate the well trainer verify that:

1. Ample water is in the holding tank.

2. The hose bibb is fully closed.

3. Both breakers are in the OFF position.

NORMAL OPERATION:

NOTE: Obtain the length of the air line installed in the well from your instructor before you determine the static level, pumping level, and drawdown of the well trainer.

1. STATIC LEVEL

   a. Connect the bicycle tire pump to the Schrader valve attached to the pressure gauge.

   b. Apply air pressure using the tire pump until the needle on the pressure gauge no longer indicates an increase in pressure.

   c. To determine the static level, multiply the maximum pressure indicated on the gauge by 2.31. Subtract this product from the length of the air line provided by your instructor.

   Example: Assume the length of the air line in the trainer was 400 feet and the maximum pressure on the gauge was 10 psi.
   400 - (10 X 2.31) = 400 - 23.1 = 376.9 feet.

2. PUMPING LEVEL

   a. Open the valve to discharge. If the right-hand tank is full of water open the valve on the left. If the left-hand tank is full, then open the valve on the right.

   b. Move the breaker for the pump to the ON position. The breaker for the jet pump is on the left-hand side of the circuit box, and the one for the submersible pump is on the right-hand side.

   c. The pump will shut off automatically.

   d. With the tire pump connected to the pressure gauge, apply pressure using the tire pump until the needle on the gauge no longer indicates an increase in pressure.

   e. To determine the pumping level, multiply the maximum pressure shown on the gauge by 2.31. Subtract this number from the length of the air line.

   Example: Assume the psi while pumping was 5.

   400 - (5 X 2.31) = 400 - 11.55 = 388.45.

3. DRAWDOWN: To determine the drawdown of the well trainer, subtract the static level from the pumping level.

   Example: 388.45 - 376.9 = 11.55 feet of drawdown

SHUTDOWN PROCEDURES

1. Move both breakers to the OFF position.

2. Disconnect the power cable from the outlet.

SUMMARY

The Air Force prefers to use ground water when it is available in quantities large enough to meet water needs. It is supplied by that step in the hydrologic cycle known as infiltration. This water exists in layers of rock or soil below the earth's surface known as aquifers. Because it is below the surface of the earth, it cannot be seen by direct observation. Some of the methods used to explore for ground water are searching for existing wells and looking for the presence of springs, lakes and swamps. Determining the type and abundance of vegetation growing in an area, geophysical methods, and digging test wells may also be used.

The ground water is obtained by drilling a well. The methods used to drill a well are down-hole percussion, rotary drilling, boring, driving, jetting, and digging. The Air Force uses the rotary method of drilling a well most often. Once the hole is constructed the other components are installed in the well. The well components are the hole, casing, screen, base plate, gravel pack and the pump assembly. Some of the problems that may occur during the operation of the wells are encrusted or corroded screens; clogged screens, gravel pack, and pores of the surrounding rock formation; and cracked casings. One of the most important tasks you must perform when operating wells is to conserve the ground water supply, but you must also prevent its contamination. You can prevent the contamination of ground water by performing sanitary surveys and protecting it against contamination from the surface, underground and through improper operation. It is your job to disinfect the well when it is built, each time the screen is cleaned, each time the pump is pulled, and when the well is contaminated.

Well operation and maintenance includes conducting well tests. These tests include measuring the static, pumping, and drawdown levels of water in the well. The records and logs used with the operation, maintenance, and testing of wells are the well chart; AF Form 996, Well Data; and AF Form 997, Daily Well Activity Record. These records help you detect problems as they arise and can help you extend the life and production of the well.

REFERENCES

AFR 85-23, Well Drilling Operations
AFR 91-26, Maintenance and Operation of Water Supply Treatment and Distribution Systems

3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

SW J3ABR56631 000-III-2

WATER TREATMENT PROCESSES

OBJECTIVES

Given information related to water clarification, match statements identifying the facts and terms which pertain to water clarification. Six of the nine must be correct.

Using information about water softening, identify facts and terms by completing ten statements. Seven of the ten must be correct.

Given information related to control of taste, odor and color, list the methods used to remove taste, odor and color in water supplies.

Given information related to water treatment processes, match facts and terms related to stabilization, disinfection, fluoridation and defluoridation. Six of ten must be correct.

INTRODUCTION

You will never find pure water in nature. All of the water that you will find in nature will have some minerals and organic matter. Water may contain small amounts of some minerals or organic matter and still be fit to drink and use. For human use, the water must be free from disease, poisons, and excessive amounts of minerals and organic matter. If it is at all possible, the water should be clear, cool and free from bad odors and taste.

An adequate supply of good water is essential to the success of any operation where humans are involved. Water is much more essential to humans than food. A human may go as much as thirty days with out food, but they can not go more than a few days without water.

As an Environmental Support Specialist, it is your job to provide an adequate supply of good, odor free water, not only to the troops in the field, but also to the troops in the rear areas that are supporting the troops in the field.

This study guide does not cover all of the information on this subject. A copy of AFR 91-26, Maintenance and Operations of Water Supply, Treatment and Distribution Systems should be obtained and researched for complete details.

INFORMATION

CLARIFICATION

The term clarification means the clearing or freeing of the water from floating or submerged debris, such as mud, clay, and living or dead aquatic organisms or growths, or other suspended material to produce a relatively clear, clean liquid. The processes included under this term are screening, and sedimentation, either plain or with coagulants. Due to the increase in pollution of our water sources, the sedimentation process alone often is not sufficient and must be followed by filtration. Plain sedimentation is now being replaced by mechanical and chemical treatment. This helps to reduce the size of the units, adds to efficiency and improves the water quality. Coagulation and sedimentation is usually followed by filtration with disinfection as a precaution against disease germs. The type and degree of treatment required will depend on the nature of the raw water, which will vary widely, depending upon its source. Ground water from wells may require only disinfection. Other ground water may contain undesirable minerals such as iron. Surface waters are more likely to be contaminated and have more turbidity. They usually need coagulation, sedimentation, filtration and disinfection.

TERMS EXPLAINED

1. **ABSORPTION:** The taking up of one substance into the body of another. Such as a sponge sucks up water, charcoal sucks up gas.

2. **ADSORPTION:** The adherence of dissolved colloidal, or finely divided solids on the surfaces of solid bodies with which they are brought into contact.

3. **CHEMICAL:** A substance, as an element or chemical compound, obtained by a chemical process or used for producing a chemical effect.

4. **CLARIFY:** To make, as a liquid, clear or pure usually by freeing from suspended matter.

5. **CLARIFICATION:** Process to become clear.

6. **COAGULANT:** A chemical, such as $Al_2(SO_4)_3$ or $FeCl_3$ that when added to water will react to form a floc.

7. **COAGULATION:** The reaction of a coagulant in water that causes it to clot, curdle, or congeal into a mass or group.

8. **COLLOIDAL:** Finely divided solids too small for resolution with an ordinary light microscope, and in suspension or solution fails to settle out.

9. **DEMINERALIZE:** To remove the mineral matter from the water.

10. **FILTRATION:** The process of passing, filtering, a liquid (water) through a filter in order to remove suspended matter.

11. **ION EXCHANGE:** A reversible interchange of one kind of ion present on an insoluble solid with another of like charge present in a solution surrounding the solid.

12. **MAINTENANCE:** The upkeep of property or equipment.

13. **PRECIPITATE:** To cause to separate from solution or suspension, to fall or come suddenly into some condition.

14. **SOLUTION:** A liquid containing a dissolved substance.

15. **TREATMENT:** The techniques or actions customarily applied in a specified situation, such as adding chemicals to water.

16. **TURBIDITY:** Very minute particles of suspended matter in water that gives an appearance of cloudiness.

17. **WATER:** A liquid that is a major constituent of all living matter and that is an odorless, tasteless, very slightly compressible liquid oxide of hydrogen, H_2O, which appears bluish in thick layers, freezes at + 0°C and boils at 100°C, has a maximum density at 4°C and a high specific heat, is feebly ionized to hydrogen and hydroxyl ions, is a good solvent, and a poor conductor of electricity.

TABLE 1 -- SOURCE AND SIGNIFICANCE OF DISSOLVED MINERAL CONSTITUENTS AND PROPERTIES OF WATER.

Constituent or Property	Source of Cause	Significance
Silica (SIO_2)	Dissolved from practically all rocks and soils, commonly less than 30 ppm. High concentrations, as much as 100 ppm, generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried over in steam or high pressure boilers to form deposits on blades of turbines. Inhibits deterioration zeolite-type water softeners.
Iron (Fe)	Dissolved from practically all rocks and soils. May also result from the corrosive action of water on unprotected iron or steel mains, steel well casings, and pumps. Surface waters may contain appreciable amounts of iron originating from industrial wastes or from acid runoff from mining operations.	On exposure to air, iron in ground water oxidizes to reddish-brown precipitate. More than about 0.3 ppm stain laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. USPHS (1962) drinking water standards state that iron should not exceed 0.3 ppm. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Calcium (Ca) and Magnesium (Mg)	Dissolved from practically all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming (see hardness). Waters low in calcium and magnesium desired in electroplating, tanning, dyeing, and in textile manufacturing.
Sodium (Na) and Potassium (K)	Dissolved from practically all rocks and soils. Found also in oil-field brines, sea water, industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers and high sodium content may limit the use of water for irrigation.
Bicarbonate $(HCO_3)^-$ and Carbonate $(CO_3)^=$	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalnity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot water facilities to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium, cause carbonate hardness.

TABLE 1 (Continued)

Constituent or Property	Source of Cause	Significance
Sulfate $(SO_4)^{=}$	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Comonly present in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. USPHS (1962) drinking water standards recommend that the sulfate content should not exceed 250 ppm.
Chloride $(Cl)^-$	Dissolved from rocks and soils. Present in sewage and found in large amounts in oil-field brines, sea water, and industrial brines.	In large amounts in combination with sodium, gives salty taste to drinking water. In large quantities, increases the corrosiveness of water. USPHS (1962) drinking water standards recommend that the chloride content should not exceed 250 ppm.
Fluoride $(F)^-$	Dissolved in small to minute quantities from most rocks and soils. Added to many waters by fluoridation of municipal supplies.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth, depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptibility of the individual (Maier, F. J., 1950).
Nitrate $(NO_3)^-$	Decaying organic matter, sewage, fertilizers, and nitrates in soil.	Concentration much greater than the local average may suggest pollution. USPHS (1962) drinking water standards suggest a limit of 45 ppm. Waters of high nitrate content have been reported to be the cause of methomoglobinemia (an often fatal disease in infants) and therefore should not be used in infant feeding. Nitrate has been shown to be helpful in reducing intercrystalline cracking of boiler steel. It encourages growth of algae and other organisms which produce undesirable tastes and odors.

Coagulation/Flocculation

Do you know how that dirty water from a lake or river is cleared up and made fit or safe to put in your body. When you, I, and all our loved ones turn the tap on to get a glass of water, do we stop to think just what has taken place to those little water molecules in order to rid it of dirt, clay and any other debris that would cause turbidity in the water. It is the removal of suspended solids, turbidity, that this section will deal with.

You will need to know that coagulation is to cause to change from a fluid, or a dissolved solution, to a solid mass by the use of chemicals. The mass or the clots formed by this action is called a "floc." It is the purpose of the "floc" to come in contact with the suspended matter in the water and grow in size and weight until it will come out of solution. The "floc" plus the turbidity that settles out is called sludge. The "floc" is formed by adding to the water, in the rapid mix tank, a chemical known as a coagulant. Coagulants come in two main groups, aluminum and iron. The most common ones are Aluminum Sulfate (Al_2 SO_4), Alum, which when put in the water that has a proper alkalinity range will ionize and form $Al(OH)_3$ which is insoluble and will settle out. The iron coagulants forms a heavy "floc." The most common ones are, Ferrous Sulfate $FeSO_4$, Copperas, Ferric Sulfate $Fe_2(SO_4)_3$, Ferric Chloride $FeCl_3$. The iron "floc" falls out of solution as Ferric hydroxide $Fe(OH)_3$. There are three steps in coagulation. As the coagulant dissolves positive ions of aluminum or iron it will neutralize the small particles of suspended matter such as colloidal clay and color. This is the first step of the coagulation reaction. For the best efficiency during the first step the coagulant should be added to the incoming water in a rapid mix, specially designed mixer or a primary measuring device such as the parshall flum may be used, for quick even mix with the coagulant and the raw water influent, this must be accomplished before the second step of treatment can occur. The second step is part of flocculation, and is accomplished in a long narrow tank that is about fifteen feet deep. If you could look in this tank you would find some large paddle wheels like you would expect to see on a old time steam boat. These large paddles turn the water in the tank at a very slow rate of speed so as to let the coagulated water come in contact with all of the clay and dirt that is in the water. As you look in a slow mix unit during operation you will see small specks, or balls forming in the water. In the third step of coagulation/flocculation we have a continuing of the floc growth. In the first step we had an electric attraction between the ions in the floc and the potential of the mud, clay and other particles in the water, in the second step you had a slow mix or stir of the floc. Now in this step the floc grows by coming in contact with the mud and dirt that is present, since the floc is sticky the turbidity in the water will stick to the surface of the floc and get large enough to settle out to the bottom of the settling tank.

When you add a coagulant to the water to form a floc, there must be the right amount of alkalinity in the raw water to react with the coagulant. If the raw water does not have the best alkalinity range, then lime or soda ash can be added to raise the alkalinity to a higher level.

Equipment and chemicals and procedures for the coagulation/flocculation process have to match the type of water being treated. This is found out by the jar test which will be covered later in this unit.

The way you would do the steps to form a good floc would be to first of all add the coagulants and coagulant aids at a given rate for the amount of raw water coming into the plant. This is done by using the right chemical feeder for the chemical being fed. Such as a dry feeder for lime or soda ash and a hypochlorinator for liquids.

Since the first reaction in the process of coagulation is a chemical reaction you will need some method of mixing the water and coagulant together very fast and even. Rapid or the flash mix, as it is sometimes called is made to give from one and one half to two and one half minutes of flash mix. The speed of this first flash mix should NOT be less than five feet per second. Rapid or flash mix can be done in one of several ways; pumps, aero-mixers, turbomixers, hydraulic pumps, agitated mixing chambers, mechanical stirrers and by using the parshall flums. Figure 10 shows a flash mixer. Although a parshall flume is a primary portion of a flow measuring device, you can use it as a very good and cheap rapid mix, since one is needed to give the flow of the incoming water anyway, and since it does not need a power source to run it, this makes it very desirable to use as a fast mix. The coagulants and coagulant aids are as listed; Aluminum sulfate, $Al_2(SO_4)_3$, which is called by the name alum. It is one of the most widely used coagulants, the floc formed is very light and has the looks of very small snow flakes. It makes a floc best in water that has a pH range of five to seven which is on the acid side. Any of the coagulants used will tend to make the water acidic. Adding lime or soda ash will keep the correct pH range needed for the forming of the floc. An example of a chemical reaction with alum and a water that has natural alkalinity of bicarbonate is:

$$\underset{\text{Water}}{18H_2O} \quad + \quad \underset{\text{Alkalinity}}{3Ca(HCO_3)_2} \quad + \quad \underset{\text{Alum}}{Al_2(SO_4)_3} \quad \longrightarrow$$

$$\underset{\text{Water}}{18H_2O} \quad + \quad \underset{\text{Gypsum}}{3CaSO_4} \quad + \quad \underset{\text{Floc}}{2Al(OH)_3} \quad + \quad \underset{\text{Carbon dioxide}}{6CO_2}$$

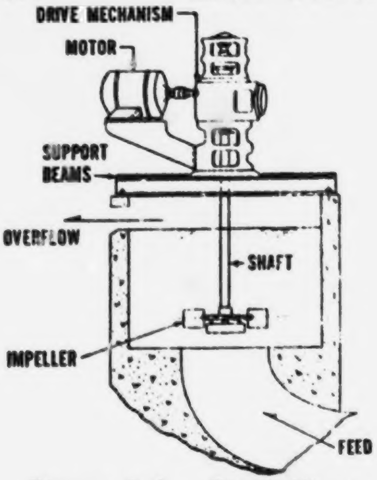


Figure 2-1. Flash Mixer

The precipitate in this case is $2Al(OH)_3$. It should be noted that all Alum added is removed during the treatment process, and that while the temporary hardness, $Ca(HCO_3)_2$ is reduced, at the same time $Ca(SO_4)_2$, permanent hardness is increased. Also note that the CO_2 content of the water has increased and as you know CO_2 + H_2O H_2CO_3, Carbonic acid, which makes the water more corrosive. If the natural (which is most likely bicarbonate) alkalinity is too low to satisfy the pH requirements for alum, then you can add lime to raise the level of alkalinity to the best level. One grain per gallon of alum requires 7.7 parts per million of bicarbonate alkalinity for a good reaction. If the alkalinity must be supplemented then for one grain per million gallon of alum you will need to add six parts per million of lime or at least 8.3 parts per million of soda ash.

A limited range in the effective pH values should be recognized. If you find that the water is too acid, then some of the alum stays in solution, inversely when the water has too much alkalinity then the alum floc tends to dissolve. The best pH range for the alum is from 5.5 to 8.0 with the best results about 7.0 pH. Ferrous Sulfate, $FeSO_4$, its common name is copperas because of its color that looks like copper oxide. If you use copperas as a coagulant, then it will react with the bicarbonate alkalinity that is present in the raw water to form a hydrous iron oxide which is then oxidized to ferric hydroxide by the dissolved oxygen in the water. You will not need any pH control if you use copperas as a coagulant, that is if the pH of the raw water is above 6.5. The best pH range for copperas is from 8.5 to 11.0. It would take lime to raise the pH to that level, since lime is a softener that makes copperas an ideal coagulant to use with the water softening process during chemical precipitation. The iron floc is a heavier floc and it is small when you compare it to the alum floc. Ferrous sulfate plus chlorine is called chlorinated copperas. The only satisfactory way of putting it in the water is to mix the Ferrous Sulfate and the Chlorine with water separately and then bring them together a few seconds just prior to putting them in the rapid mix zone. Ferric floc has been noted at a low pH of 3.5, that makes its range of coagulation wider than that of copperas. Ferric salts are much more corrosive to use than copperas. When you add chlorine to ferrous sulfate you will find that it will yield both ferric sulfate and ferric chloride. Any excess chlorine may be used in the coagulation basin as an aid to coagulation and in keeping the basin free of algae. The best pH to have when using chlorinated copperas is from 5.0 to 11.0 with the very best results noted when the water is on the alkaline side of the pH. Ferric sulfate, $Fe_2(SO_4)_3$, is used in some treatment plants, but it has to have a special solution arrangement because of its slow solubility in cold water. Ferric chloride, $FeCl_3$, can be made at the water plant by passing chlorine solution over some scrap iron, or it can be bought as a solid, powder, or a solution. When used with the erdlator it is obtained in one pound bags for ease of mixing the correct concentration of feed dosage.

Coagulant aids do not form or make the floc when they are added to the water alone. The aids, when added to the water that has a coagulant in it, makes the floc tougher and stronger so that it will have a better settling rate, and not break up as easy when the water is run through the plant at a faster than normal rate of flow. The most common used coagulant aids are lime, soda ash, chlorine, activated silica, organic polymers and bentonite clay.

Lime is used to raise the pH of the water to the best alkalinity level for the coagulant being used. It can be added either as calcium oxide (quick lime) which reacts with the water and forms calcium hydroxide, or you can add calcium hydroxide (slaked lime), both of these forms of lime are fed by a dry chemical feeder. Lime is also added to the water for softening and will be covered in more detail later.

Sodium Carbonate, its common name is soda ash. Soda ash is used to raise the pH or alkalinity of the water and is also used to soften the water. Like lime it can be fed with a dry feeder. It is more expensive than lime but you will find that a shorter coagulation time is required with soda ash than with lime.

Chlorine is or can be added to the water for many reasons. When you use it as a coagulant aid it will convert ferrous sulfate, a coagulant, to the ferric sulfate and ferric chloride forms so it will precipitate. When it is added to sodium silicate it will react to form activated silica which is used by plants that operate near or over their normal operating rate of flow.

Activated silica is made by adding sodium silicate plus chlorine, it works well with water that is very low in turbidity.

Organic polymers are aids that have molecules which consist of long chains of atoms. This long chain of atoms has many reaction groups or sites all along the full length of the chain. An example of the way that it groups together is starch or cellulose.

Bentonite Clay aids by providing a solid surface where the first formation of the floc can start to grow in size and gain weight so that it can fall out of solution. You would use the clay in water that has colloidal solids, suspended matter too small to settle out under normal treatment.

The coagulant dosage required for the raw water is based on a number of things; the pH, temperature, turbidity, dosage, time, chemical composition, and the speed of mixing. Some of these things you will not be able to measure, so it will be impossible for you to calculate the amount of coagulant to use by a theory or formula. One way that you can find out the dosage to use is by the jar test.

The jar test is used to find the minimum amount of coagulant that will form a pin head size floc and settle out leaving the water clear. The dosage should be such that not more than 15 Mg/L of turbidity goes over into the filter. In all cases you should make sure that all of the water entering the filter bed has been flocculated and settled. One way to tell if this action has taken place is by looking to see if the water between the small particles of floc is clear. You can find the procedures for performing the jar test in the 566X1 CAREER LADDER LABORATORY MANUAL ALL COURSES.

Flocculation

After the water leaves the fast mix area the flow rate of the water should be slowed to a speed of 0.75 to 1.0 feet per second for a period of 20 to 30 minutes. Note: that excessive stirring of the coagulated water would break up the small, light, loosely bound floc and then the proper settling tank. Slowing the flow rate down is done by changing the water flow from a narrow shallow flow to a wide, deep flow in the flocculator. The flocculator has large paddles that covers the entire width of the tank and gently stirs the water so that the coagulated water will come in contact with all of the turbidity that is present. The floc that forms is of an opposite polarity than that of the suspended solids; because of this, the suspended solids sticks to the floc causing it to grow in size. The flocculator which is also called slow mix can be seen in figure 2-2.

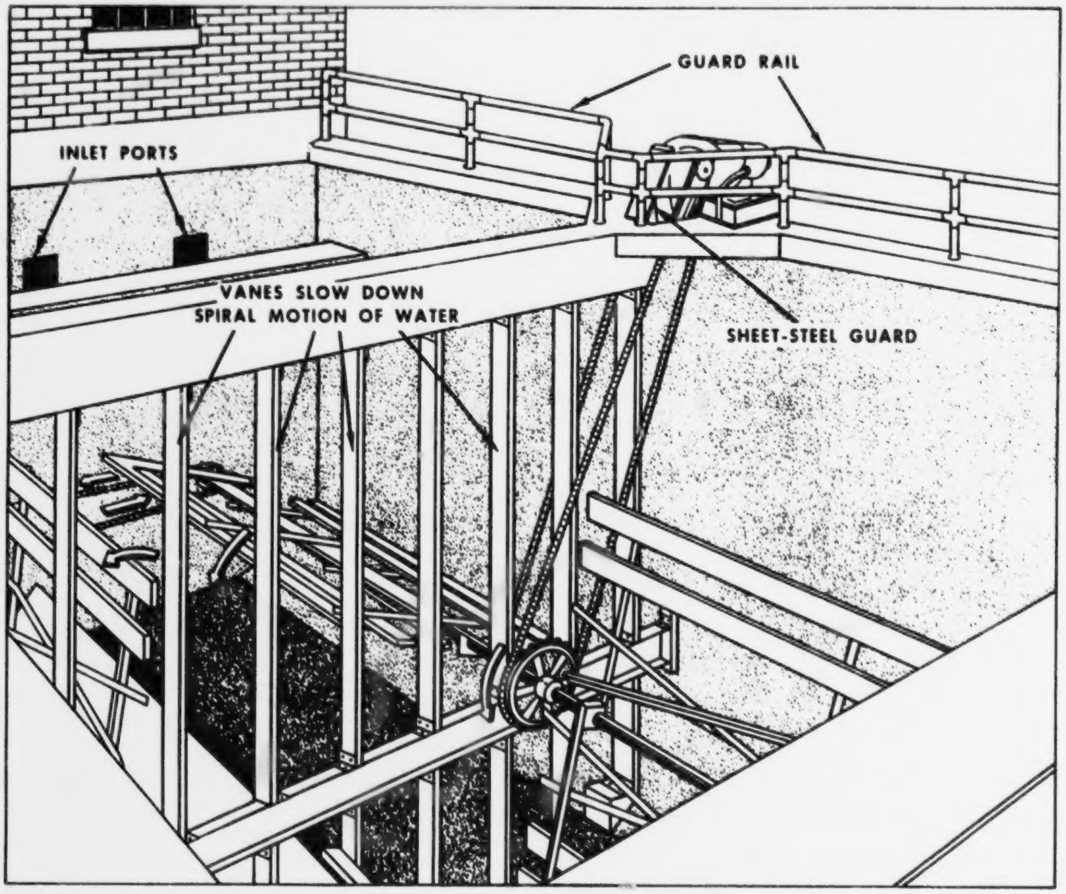


Figure 2-2. Rotary Flocculating Equipment

Sedimentation

Sedimentation is the process of removing settleable materials. This is done by decreasing the speed of flow to lessen the ability of the water to hold particles in suspension. Many particles are removed by nature in this way during storage of the water in ponds and reservoirs. In very turbid waters, pretreatment of the water by sedimentation without the use of chemical coagulants is provided in specially built basins, in which the speed can be controlled.

In a water treatment plant, sedimentation usually follows mixing and flocculation, for the removal of floc masses prior to filtration. In all probability, with effective flocculation a satisfactory filter effluent could be produced without the use of sedimentaiton, but the filters would clog very quickly and the operation costs would be so high that the process would not be practical.

A sedimentation basin is a structure through which water flows at such an extremely low velocity that suspended material will settle towards the bottom of the basin, with a relatively clear water passing out of the tank. In general, detention periods (volume of basin divided by rate of flow through the basin) between four and five hours and horizontal velocities less than three (one or two) feet per minute are specified. It should be emphasized that present practice is to remove as much floc and other settleable material as possible by coagulation and sedimentation. This increases rates of filtration and length of filter runs, without deterioration of finished water quality.

Probably the most important features in the operation of a sedimentation tank are: (1) the introduction of water into the tank with a minimum turbulence, (2) the prevention of short circuiting or direct currents between inlet and outlet, and (3) the removal of the effluent with a minimum disturbance so that settled material will not be carried out of the tank.

Filtration

The filtration process is an important part of water treatment. When used to filter water for human use, it removes fine inorganic and organic materials. Incidentally it may reduce the bacterial content and the contaminants which cause taste and odor. The objective of filtration is to produce a clear sparkling water.

Water filters are classified into two types; slow sand and rapid sand filters. Both filters can be used in Air Force installations; however, the rapid sand filters are the most commonly used.

SLOW SAND FILTERS: These filters contain fine-grain sand and have low filtration rates. These are normally used when coagulation is not included in the treatment process; however, use of slow sand filters by the Air Force has been practically discontinued because of their initial high cost, the high cost of labor required to clean them, and the large surface area of land required.

RAPID SAND FILTERS: These filters are normally used by the Air Force in modern water treatment plants. The two types of rapid sand filters discussed are gravity and pressure.

GRAVITY FILTERS. See figure 2-2. Gravity filters are usually open top rectangular concrete boxes about ten feet deep. An underdrain system at the bottom of the gravity type filter is covered by about 12 inches of gravel which in turn supports a 24 to 30 inch layer of fine filter sand or other filtering agent (see figure 2-3).

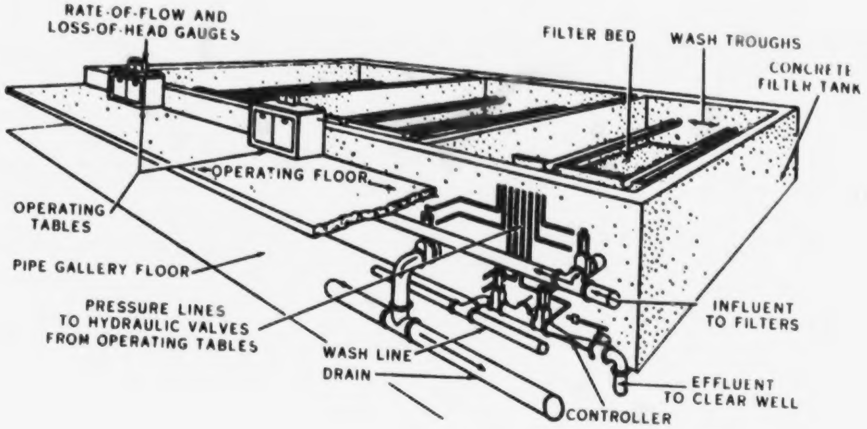


Figure 2-3. Gravity Type Rapid Sand Filter

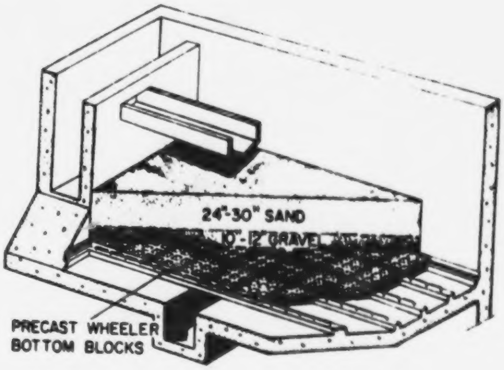


Figure 2-4. Cutaway of Gravity Type Filter

Gravity filters are normally designed to filter about two gallons per minute per square foot of filter-bed area; however, as much as four gallons per minute per square foot can be filtered during an emergency if prior treatment by flocculation and sedimentation produces very low turbidity, and if pre-chlorination and post-chlorination are disinfecting the water efficiently. Approval must be obtained from the major command to operate filters at rates in excess of 2 gpm per square foot.

Pressure Filters. See figure 2-5. Pressure filters have the filter bed enclosed in a pressure vessel. Water is either pumped into the vessel and forced through the filter or is drawn through the filter by a suction pump. Pressure filter tanks can be installed either vertically or horizontally (see figure 14). This type of filter will operate on the same principle and at the same flow rate as gravity filters.

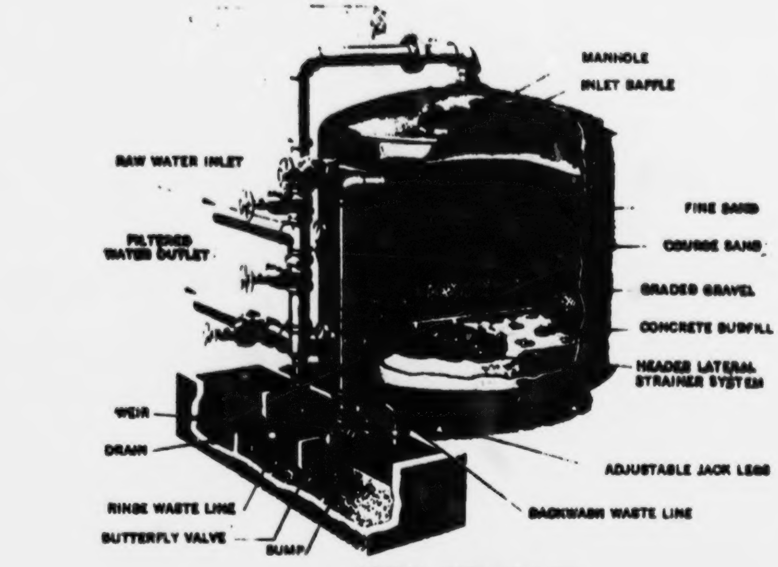
Filter Media. The filter media most commonly used by the Air Force water systems are (1) sand, (2) anthrafilt, and (3) filter gravel. Each filter agent must meet rigid specifications.

Filter Sands. Filter sand is made up of sharp or rounded durable grains of clean quartz or quartzite material. The quartz will be between 0.35 and 0.70 millimeters. Of course, the size of the sand grain will be used as an index to determine the filtration rate.

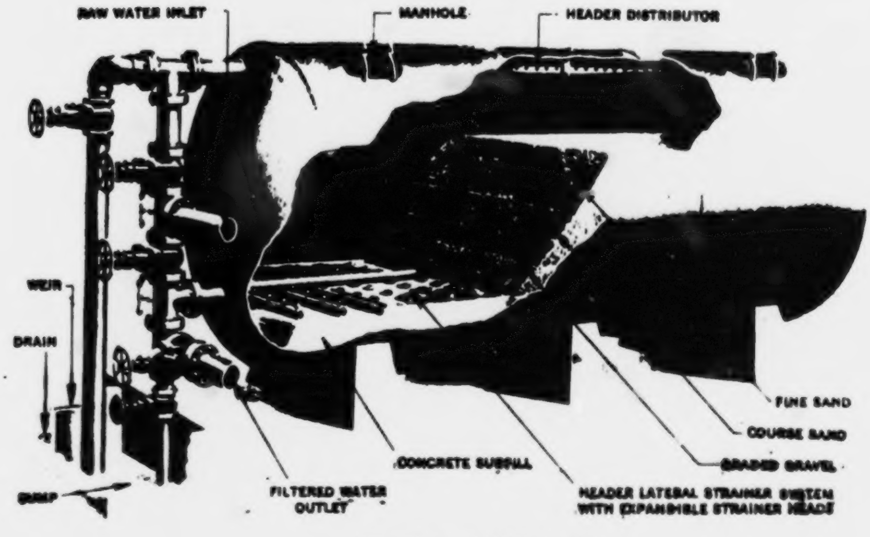
Anthrafilt. Anthrafilt is a filtering medium obtained from freshly mined anthracite coal. Some of the specifications of anthrafilt are (1) it must be free of dirt and other foreign material; (2) the anthrafilt grains will be 0.65 to 0.75 mm in diameter; (3) ash content is less than eleven percent; and (4) it will weigh about 53 pounds per cubic foot.

Filter Gravel. Filter gravel has three primary purposes: (1) it supports the sand; (2) it permits water to flow freely to the underdrain; and (3) it aids in distributing wash water to all parts of the sand in a uniform manner. Specifications that must be met are: (1) it must consist of hard, rounded, and durable pebbles; (2) it must weigh 100 pounds per cubic foot; and (3) it must be washed and be free of loam, sand, clay, dirt, shells, and other foreign matter.

Design Features. The purpose of underdrains is to provide an outlet for the water after it has passed through the filtering agents. Design of the underdrain system is controlled mainly by the wash water requirements. This is so because the rate of application of wash water is greater than the rate of filtering.


MANHOLE
INLET BAFFLE
RAW WATER INLET
FILTERED WATER OUTLET
FINE SAND
COURSE SAND
GRADED GRAVEL
CONCRETE SUBFILL
HEADER LATERAL STRAINER SYSTEM
WEIR
DRAIN
ADJUSTABLE JACK LEGS
RINSE WASTE LINE
BACKWASH WASTE LINE
BUTTERFLY VALVE
SUMP

VERTICAL PRESSURE FILTER


RAW WATER INLET
MANHOLE
HEADER DISTRIBUTOR
WEIR
DRAIN
FINE SAND
COURSE SAND
GRADED GRAVEL
CONCRETE SUBFILL
SUMP
FILTERED WATER OUTLET
HEADER LATERAL STRAINER SYSTEM WITH EXPANSIBLE STRAINER HEADS

HORIZONTAL PRESSURE FILTER

Figure 2-5. Pressure Filters

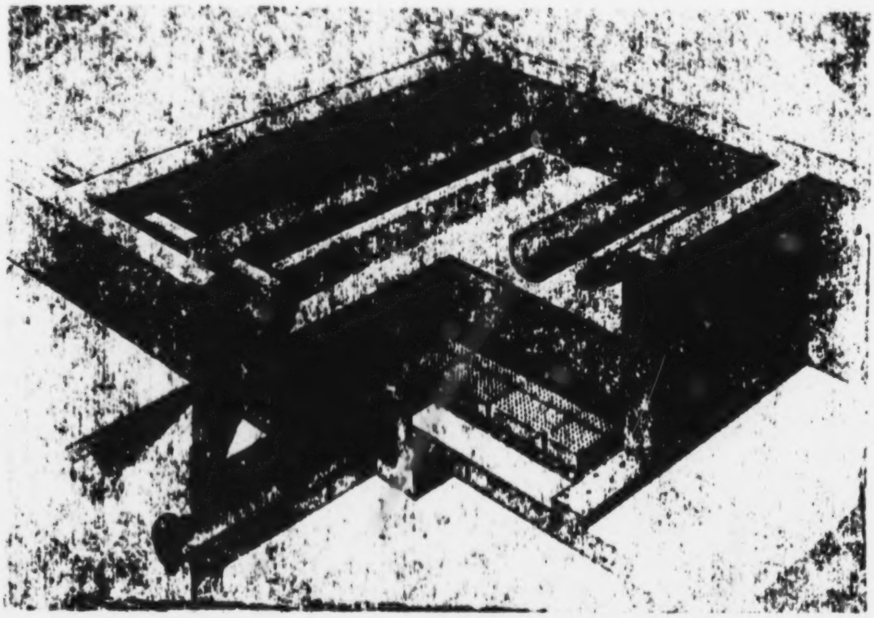
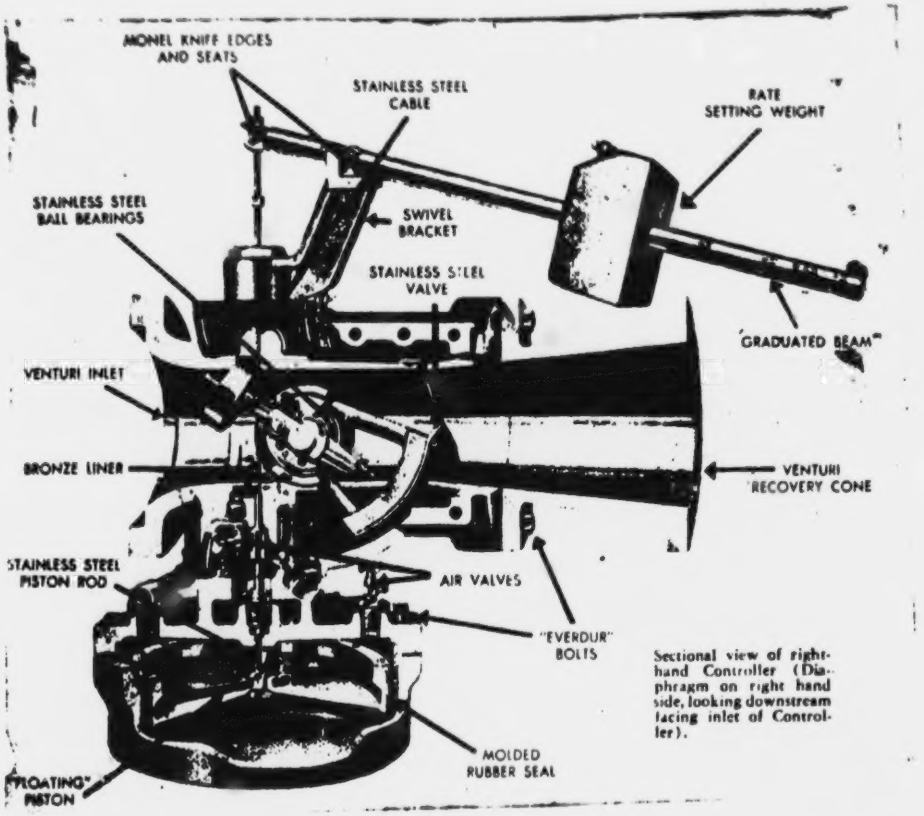


Figure 2-6. Underdrain System

In order to be able to understand the operation of filters, you must have a working knowledge of the filtering equipment, such as, the rate-of-flow controller, loss-of-head gage, wash-water controller, and rate-of-flow indicator. Each one of these components will be described and then integrated in an explanation of filter operation.

The purpose of the rate-of-flow controller (see figure 16) is to regulate the flow of water through a filter bed at two gallons per minute per square foot. When a filter bed is first put into operation or if it has been washed recently, the water will flow through it too rapidly for effective filtration. As a result, the filter outlet line must be restricted to reduce the flow of the water. As the filter bed becomes clogged with foreign matter, the filtration flow rate decreases. The restriction will then be reduced in order to maintain a stable filtration rate. A pressure operated automatic mechanism known as a rate-of-flow controller will accomplish the steady flow rate through the filter. The rate-of-flow controller is usually installed in the water filter outlet line. Its operation is controlled by filtered water flowing through a venturi tube. Pressure differentials will be produced by the venturi tube and will actuate a balanced valve. The balanced valve in turn will affect the flow rate by partially opening or closing the flow valve.

Rate-Of-Flow Indicator. The flow rate of the water out of the filter is measured by the rate-of-flow indicator. It will usually consist of a venturi meter which is located in the filter outlet line. The indicating instrument itself will be installed on the operating floor where it can be observed by the operator.


MONEL KNIFE EDGES AND SEATS
STAINLESS STEEL CABLE
RATE SETTING WEIGHT
STAINLESS STEEL BALL BEARINGS
SWIVEL BRACKET
STAINLESS STEEL VALVE
"GRADUATED BEAM"
VENTURI INLET
BRONZE LINER
VENTURI RECOVERY CONE
STAINLESS STEEL PISTON ROD
AIR VALVES
"EVERDUR" BOLTS
MOLDED RUBBER SEAL
"FLOATING" PISTON

Sectional view of right-hand Controller (Diaphragm on right hand side, looking downstream facing inlet of Controller).

Figure 2-7. Rate-of-Flow Controller

In some equipment it will be included with the loss-of-head gage or the rate-of-flow controller. This gage must be observed frequently since a constant and controlled rate of filtration is necessary. Changes in the filtering rate may cause breaks in the filter bed which would allow portions of the water to pass through the filter without being filtered.

Loss-Of-Head Gauge. As the water passes through the filter, foreign matter is deposited in the filter. This foreign matter produces a greater resistance to the flow of the water through the filter bed and underdrain; consequently, there is a loss in head pressure between the inlet and outlet of the filter. This loss of head pressure is measured by the loss-of-head gauge (see figure 2-8). This gauge is operated by two floats, one at the surface of the water in the filter and the other at the static operating level of water in the underdrain. These two levels of pressures will be reflected by the calibrated face of the loss-of-head gauge and portrays a very accurate guide for efficient filter operation. This gauge should be checked periodically for operation and accuracy. Loss-of-head gauge erratic readings can identify such problems as (1) cracks in the filter bed surface, (2) improper operation of the rate-of-flow controller, (3) malfunctioning automatic outlet valves, and (4) the need for washing of the filter.

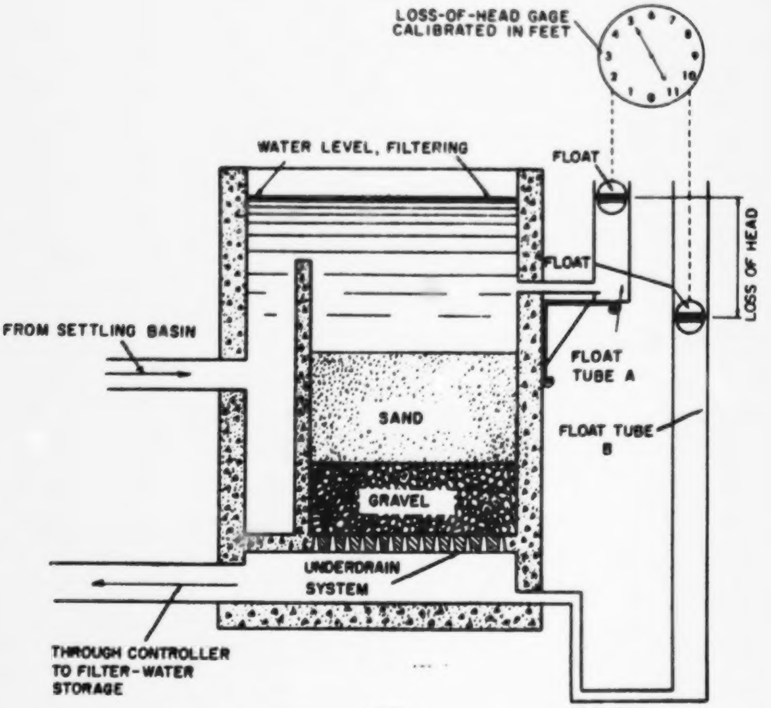
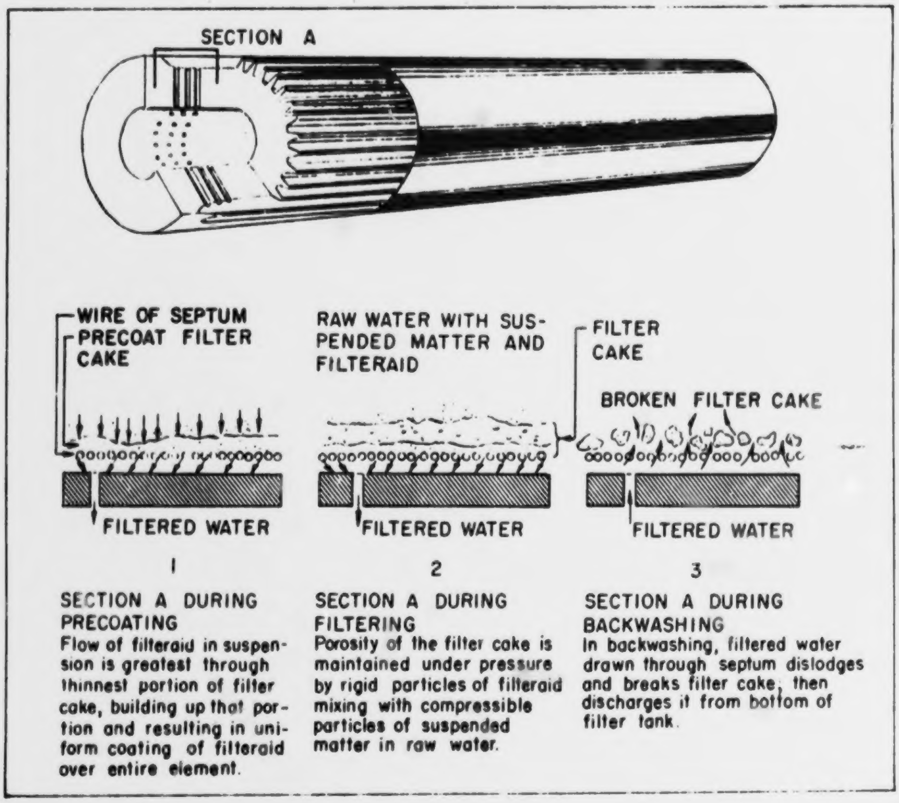

LOSS-OF-HEAD GAGE CALIBRATED IN FEET
0
1
2
3
4
5
6
7
8
9
10
11
WATER LEVEL, FILTERING
FLOAT
FLOAT
LOSS OF HEAD
FROM SETTLING BASIN
FLOAT TUBE A
SAND
FLOAT TUBE B
GRAVEL
UNDERDRAIN SYSTEM
THROUGH CONTROLLER TO FILTER-WATER STORAGE

Figure 2-8. Loss-of-Head Gauge Operation

Wash-Water Controller. When the filter has become clogged and must be washed, a wash-water controller is used to control the flow rate of the water from the wash-water tank through the filter. This valve of controller must not be opened too quickly as it may cause air, which has accumulated in the bottom of the filter, to compress. This air pressure can be released only through the filter bed which will violently disturb the arrangement of the sand and gravel. The valve control mechanism will be located on the operating floor.

Filter Operation. In reference to the operation of filters refer to Figure 2-7. An outlet pipe transports water from the sedimentation basin to the filter. The water will be discharged against the filter baffle. This prevents the water current from disturbing the filter bed. The incoming water flows up and over the filter. The water filters downward through the sand and gravel into the underdrain system. The outlet flow of the water from the filter is regulated by the rate-of-flow controller. The filtered water is collected at this point in the process in a filtered-water reservoir called a clearwell. The main operating difficulties in water filters are: (1) mud or mud ball accumulation, (2) sand incrustation, (3) air binding, (4) sand clogging, (5) formation of micro-organisms and (6) ice formation.


SECTION A
WIRE OF SEPTUM
PRECOAT FILTER CAKE
RAW WATER WITH SUSPENDED MATTER AND FILTERAID
FILTER CAKE
BROKEN FILTER CAKE
FILTERED WATER
FILTERED WATER
FILTERED WATER
1
2
3

SECTION A DURING PRECOATING
Flow of filteraid in suspension is greatest through thinnest portion of filter cake, building up that portion and resulting in uniform coating of filteraid over entire element.

SECTION A DURING FILTERING
Porosity of the filter cake is maintained under pressure by rigid particles of filteraid mixing with compressible particles of suspended matter in raw water.

SECTION A DURING BACKWASHING
In backwashing, filtered water drawn through septum dislodges and breaks filter cake, then discharges it from bottom of filter tank.

Figure 2-9. Pressure Filter Element

Pressure Filters. There are two types of pressure filtering agents, they are: sand and diatomaceous earth. Pressure filters (figure 2-5) will be used in filtering the main water supply as well as for swimming pools. The diatomaceous earth pressure filter (figure 2-8) will be used primarily because it will require less space than sand filters and it will make sparkling clear water. Diatomaceous earth is composed of skeletons of countless tiny one-celled animals called diatoms which, when specially prepared, looks like powdered chalk. The diatomaceous earth will build up on the filtering element and form a cake deposit. This causes a formation of fine pores between the particles, and filters the water as it passes through the cake deposit.

The filtering elements, (figure 2-9), of the pressure filter in the center of the tank are cylindrical and perforated. A single depth of fine wire is wound around the cylinder. This fine wire element is close enough to stop the diatomaceous earth from passing through the filter. The diatomaceous earth deposits evenly to form a thin coating, called the pre-coat, over the filter element.

Pressure filters are much more widely used than gravity filters. They are usually built to withstand a pressure of 50 to 65 pounds per square inch. Vertical filters range in size from 1 to 10 feet in diameter. Horizontal filters are usually about 10 feet in diameter and about 25 feet in length. The operation of these filters is basically the same as gravity filters except that water is forced through the filter bed under pressure.

The flow rate through a pressure filter is about 3 gpm per square foot of filter area. When the head loss reaches 5 pounds per square inch, the filter area. When the head loss reaches 5 pounds per square inch, the filter should be backwashed. The backwash rate is about 12 to 15 gallons per minute per square foot.

The main advantages of pressure filters over the gravity type are (1) they are less costly to install; (2) they are free from air binding; and (3) they eliminate double pumping. The biggest disadvantage is that the efficiency of operation of the filter cannot be directly observed. A typical vertical steel shell pressure filter is shown in figure 2-10.

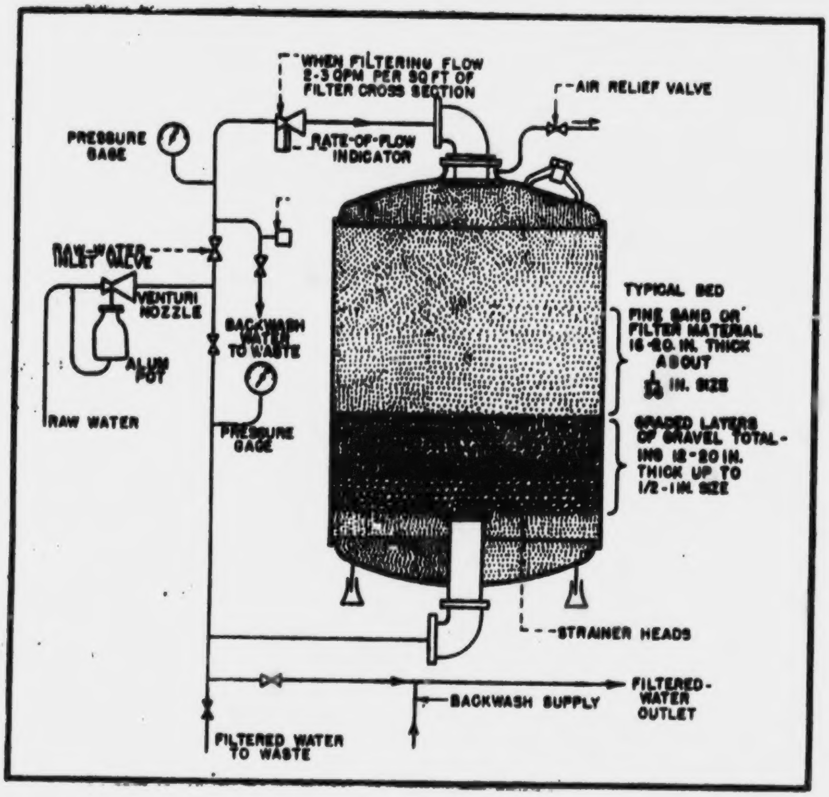
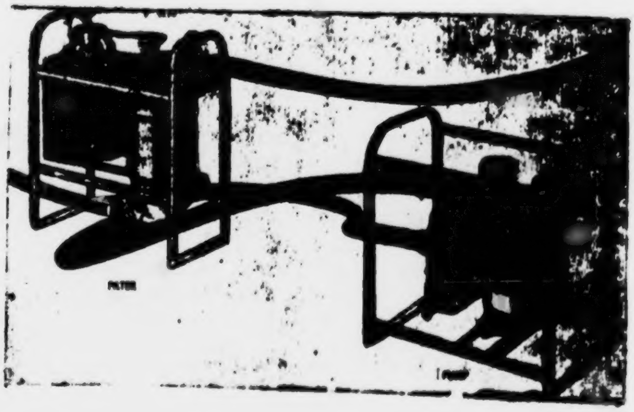
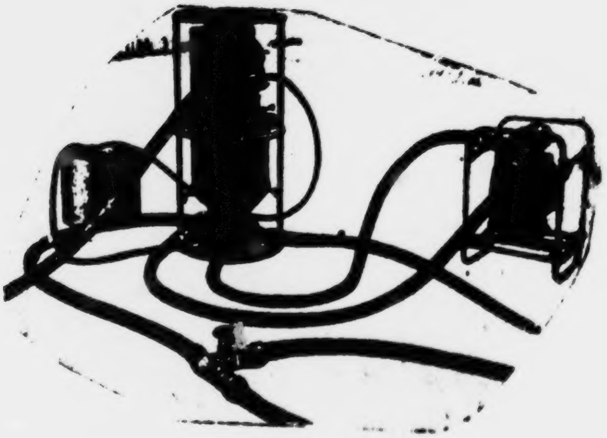

WHEN FILTERING FLOW 2-3 GPM PER SQ FT OF FILTER CROSS SECTION
AIR RELIEF VALVE
PRESSURE GAGE
RATE-OF-FLOW INDICATOR
RAW-WATER INLET VALVE
VENTURI NOZZLE
BACKWASH WATER TO WASTE
ALUM POT
RAW WATER
PRESSURE GAGE
TYPICAL BED
FINE SAND OR FILTER MATERIAL 16-20 IN. THICK ABOUT IN. SIZE
GRADED LAYERS OF GRAVEL TOTALING 12-20 IN. THICK UP TO 1/2-IN. SIZE
STRAINER HEADS
FILTERED-WATER OUTLET
BACKWASH SUPPLY
FILTERED WATER TO WASTE

Figure 2-10. Vertical Steel Shell Pressure Filter

Diatomaceous Earth Filters. Diatomite purification equipment is available in 15, 35, and 50 gpm portable sets (see figure 2-10). This equipment and auxiliary supplies consist of a pressure filter unit, a diatomite feeding apparatus, pre-coat tank, fabric tanks, gasoline-driven pumping sets, suction hose, coagulating chemicals, two chemical



Diatomite water purification set No. 2, 15 gpm



Diatomite water purification set No. 3, 35 gpm feed baskets, a measuring container, and a chest containing discharge hose, fittings, residual chlorine, and pH testing equipment. The variances in the 15, 35, 50 gpm diatomite purification equipment or sets is as follows:

	Set No. 2	Set No. 3	Set No. 4
Average Output	15 gpm	35 gpm	50 gpm
Pumping Sets	4 each	4 each	5 each
Fabric Tanks	4 each-500 gal.	3 each-3,000 gal.	4 each-3,000 gal.
Suction Hoses	1 inch	1-1/2 inch	2 inch

The purpose of the diatomite equipment is to provide potable and safe water for Air Force personnel in the field. All the purification sets mentioned above were specifically designed to remove all amoebic cysts and the cercariae of schistosome. Pre-treatment is necessary for efficient operation of a diatomite filter. The complete layout for all purification sets is similar, as represented in figure 2-11, and includes the process of coagulation, sedimentation, disinfection, and filtration to produce water of the highest quality regardless of the turbidity of the source.

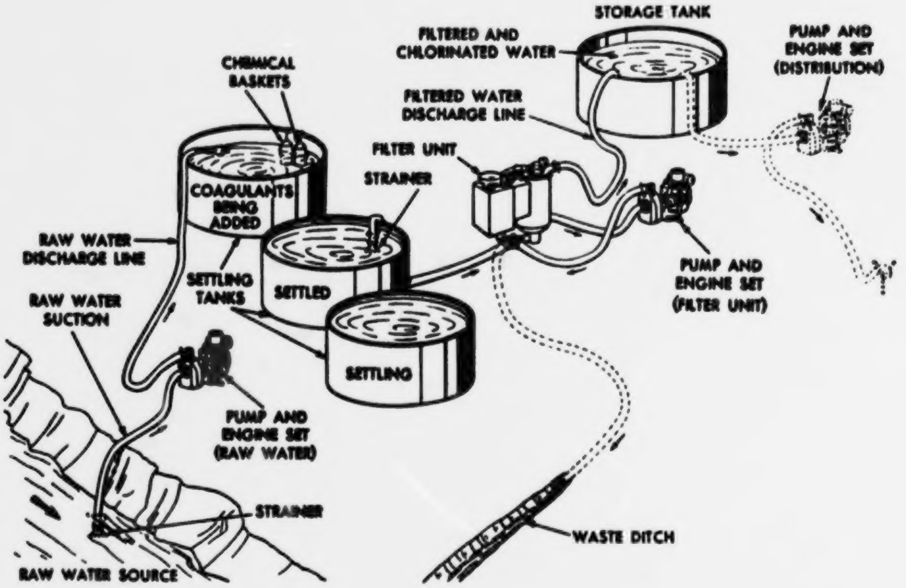

STORAGE TANK
FILTERED AND CHLORINATED WATER
PUMP AND ENGINE SET (DISTRIBUTION)
CHEMICAL BASKETS
FILTERED WATER DISCHARGE LINE
FILTER UNIT
STRAINER
COAGULANTS BEING ADDED
RAW WATER DISCHARGE LINE
SETTLING TANKS
SETTLED
PUMP AND ENGINE SET (FILTER UNIT)
RAW WATER SUCTION
SETTLING
PUMP AND ENGINE SET (RAW WATER)
STRAINER
WASTE DITCH
RAW WATER SOURCE

Figure 2-11. Portable Water Purification Equipment

The maximum production of the purification sets is as follows:

Rated Capacity or Filter	Maximum Output Per 20-Hour Day
15 gpm	15,000 to 18,000 gallons
35 gpm	40,000 to 45,000 gallons
50 gpm	50,000 to 60,000 gallons

The equipment just described is referred to as batch type equipment. The batch type equipment will eventually be replaced by the continuous flow type of purification equipment (see figure 2-12). The continuous flow type will allow purification of water under all climatic conditions. Detailed instructions on operation and layout are found in TM 5-4610-202-10, TM 5-4610-203-10, and TM 5-4610-204-10 which corresponds to the federal stock number.

Figure 2-12. Van Type Water Purification Unit

EXERCISE III-2-2a

INSTRUCTIONS

PART 1

Complete the following questions. You can consult your instructor if you have any questions.

1. What is the meaning of the term clarification? ______________________________

2. What is the fastest method of clarification? ______________________________

3. What characteristic must the water have in order for $Al_2(SO_4)_3$ to form a floc?

4. What is the purpose of rapid mix? ______________________________

5. What is the purpose of slow mix? ______________________________

6. What is used to measure the flow of water that could also be used for rapid mix?

7. List two comounds that would add alkalinity to the water?

8. How would you determine the minimum dosage of coagulant? ______________________________

9. What is the process used to remove settleable material from the water?

10. What is the purpose of filtration? ______________________________

11. Which filter is commonly used by the Air Force? ______________________________

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____________________ ____________________

12. What device maintains the flow through a filter at two gal./min/sq ft?

____

13. The difference between filter inlet and outlet pressure is referred to as

____________________ of ____________________.

EXERCISE III-2-2a

PART II

In Figure 1, place the number of components on the blank line to properly associate the two items.

______ PARSHALL FLUME OR RAPID MIX ______________________.

______ RAPID SAND FILTER ______________________.

______ ELEVATED STORAGE TANK ______________________.

______ IMPOUNDED RESERVOIR ______________________.

______ POST CHLORINATION ______________________.

______ SLOW MIXING AND FLOCCULATION ______________________.

______ HIGH LIFT PUMP ______________________.

______ FEEDER LINE ______________________.

______ SEDIMENTATION BASIN ______________________.

______ FILTERED WATER RESERVOIR ______________________.

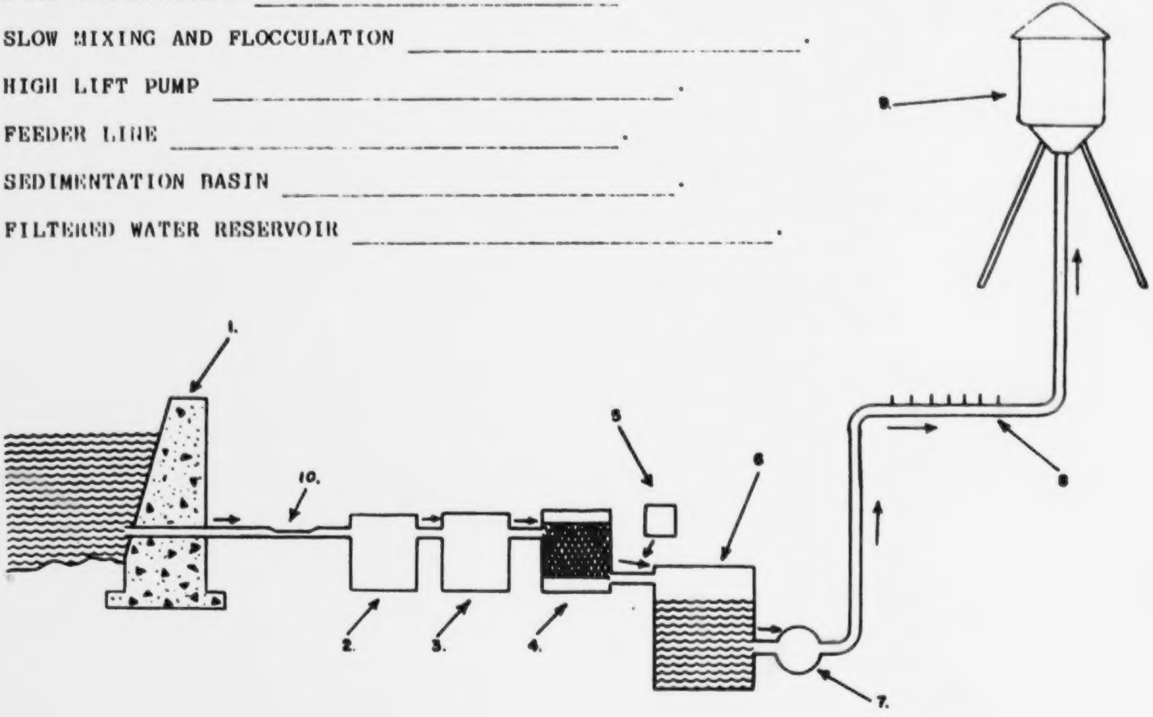


FIG. 1. WATER TREATMENT PLANT

EXERCISE III-2-2a

INSTRUCTIONS

PART III

Find a term in the right hand column which best fits each statement in the left hand column, then place the letter preceding the selected term in the blank preceding the statement.

1. ________ used to remove dissolved gases, iron and manganese from water
2. ________ located near the plants, used for flash mix of chemicals and water.
3. ________ used to keep floc in suspension
4. ________ may be located at various points in the plant, and operate on the centrifugal force principle
5. ________ has a long retention period, 6 to 8 hours
6. ________ a retention period of 1 to 2 hours
7. ________ a storage and contact chamber
8. ________ stores water and provides pressure for emergencies
9. ________ removes suspended solids not removed by settling
10. ________ used for the injection of HTH solution

a. elevated tank
b. clearwell
c. filter
d. accelator
e. pump
f. settling tank
g. slow mixer
h. hypochlorinator
i. aerator
j. rapid mixer

TASTE, ODOR, AND COLOR

INFORMATION

Did you ever comment on how bad the water tasted, smelled, or even looked while you were visiting another part of the country? Sure, most of us have. Because of this fact, your job as an environmental support specialist will be to treat the water at your base to everyone's satisfaction. Produce, as near as possible, a water that is pleasing to the taste, odorless, sparkling clear, and safe to drink. This is what we call "potable" water. Water that is pleasing to the taste but may not be safe to drink is called "palatable."

Tastes and odors are more prevalent in surface water than in ground water, and cold water has less taste and odor than warm water. The odors are usually described as aromatic, disagreeable, fishy, moldy, sweetish, and vegetable. The strength of the odor varies from very faint to very strong.

Water may also have a disagreeable taste because it contains hydrogen sulfide and free chlorine. Free chlorine may originate in the purification processs. The presence of bone and fish oil is especially undesirable.

The principal cause of unpleasant taste and odor in water are: (1) Industrial waste such as canneries, chemical manufacturing plants, and from coke plants etc. Leakage from the sanitary waste water system into the water supply would also be industrial waste. (2) Algae growth, any of a various primitive, chiefly aquatic (living or growing in or on the water) one celled or multicellular plants that lack true stems, roots, and leaves but usually contain chlorophyll, a green coloring found in plants. (3) Organic matter is composed of carbon, therefore plants and animals living in or near the water can give the water taste and odor. The decomposition (organic decay) of dead plants and animals can not only give bad taste and odor to the water, but make the water unsafe. (4) Dissolved gases such as H_2S, Hydrogen Sulfide, gives the water a rotten egg taste and odor. H_2S occurs in sulfur springs, well water, and from decaying organic matter. It is a colorless gas, slightly heavier than air, moderately soluble in water, and very toxic. (5) Iron is usually found in well water and also from the lower levels of deep lakes. If iron is present in the water, then manganese will also be present. Some bacteria need iron as a food. Objectionable concentrations of iron will precipitate in the water and death of the organisms will create disagreeable tastes and odors.

Taste and Odor Control chemicals may be added to the raw water source, as it enters the plant, at the rapid mix, depending on the method of control. Treatment may be added at any stage of treatment. Some of the treatment methods will be covered in the following paragraphs.

Algae Control. The presence of algae does not make water unsafe. But, uncontrolled algae growth frequently is the cause of unpleasant tastes and odors and it may clog pipes and filter beds, thus lowering their efficiency. Filtration difficulties are generally caused by a small group of diatoms. Taste and odor problems are generally caused by a wide variety of algae, the type and size of the problem varying with the algae concerned. Algae growth occurs mainly in large open reservoirs, in sluggish streams, and in surface supplies. Algae must have sunlight to grow.

(1) Copper Sulfate. Copper sulfate treatment is most effective if started early in the season before heavy algae concentration has formed. The treatment is repeated whenever algae growths reappear. If copper sulfate can be applied by solution feeder to water entering the reservoir, continuous application of lower concentrations can be used instead of intermittent treatment. This usually results in the most efficient control of algae growths. Copper sulfate treatment should be started when the algae count exceeds 20 organisms per millimeter of water, as measured by the centrifugal or Sedgewich-Rafter funnel methods or by microscopic examinations.

(a) The simplest, though not the best method, of applying copper sulfate is to tie a bag of copper sulfate crystals to a boat and cover the reservoir in a definite zigzag pattern.

(b) In reservoirs needing frequent treatment, the best method is to spray copper sulfate solution on the water surface from a spray unit mounted in a boat. Apply the solution evenly to avoid overdosing shallow areas.

(2) Chlorine. Chlorine may be applied as hypochlorite solution or chlorine gas. Hypochlorite is sprayed on the water from a boat-mounted spray unit. Gas is fed from a boat-mounted chlorinator through a submerged diffuser into the water. Either may be fed continuously when controlled dosage can be applied to water entering the reservoir.

(3) Activated Carbon. In large reservoirs and impounded supplies, activated carbon is applied by spray from a boat. In small basins, regular spraying and hand spreading can be used. In filtration plants carbon is usually added before coagulation. Suspended carbon carried to the filters is effective in removing odors, although shortening of filter runs may occur.

(4) Mechanical. Filters may also be used to control algae in water. Both pressure and gravity filters may reduce algae with the help of pretreatment.

Iron and manganese removal when dissolved iron exceeds 0.3 ppm, it causes an unpleasant taste and strains plumbing fixtures. If it goes over 2.0 ppm, nobody likes to use it.

Iron is rarely found in surface waters but is often found in well water. If the dissolved iron does not exceed 2 to 3 ppm, staining of kitchen and bathroom fixtures can be prevented by treating with polyphosphate. Above 3 ppm iron, removal treatment is necessary.

Aeration units are most commonly used to remove iron. Any method that can get air in the water will do. Some cities use a water fountain effect while others use a wooden tower with open mesh slats in it.

The object of aeration is to get oxygen to combine with the dissolved iron and form an iron compound that is not soluble in water. When the iron compound is no longer soluble it will come out of solution and can be caught up by flocculation then filtered out.

An added benefit of aeration is an improvement in taste and odor.

Aeration consists essentially of exposing as much water surface as possible to the air. During aeration, gases dissolved in the water supply are released to the atmosphere; soluble iron salts are oxidized and become insoluble so they can be removed by settling. Aeration raises the pH by eliminating dissolved carbon dioxide but increases corrosiveness by increasing the amount of dissolved oxygen. Methods of aeration include spraying water up over a shallow receiving basin, and forcing air into a basin with diffusers or mechanical pump type aerators.

Activated carbon is specially treated granular or powdered carbon which, because of its increased surface area, will adsorb larger quantities of dissolved gases, liquids, and finely divided solids than ordinary carbon. It is highly effective in taste and odor control, provided that the type of activated carbon used meets required standards, the dosage is correct, the carbon is mixed intimately with the water, and the carbon is in contact with the water for an adequate period of time.

Because of the wide range in waters, no general rule can be given for activated carbon dosage. The dose required at each plant must be determined by periodic laboratory tests. A carbon dose of 3 ppm removes most tastes and odors from water. However, if the tastes and odors are caused by pollution from industrial wastes, the dose may have to be increased to 8 ppm, or even 20 ppm at times.

Activated carbon may be applied to water at one or more points depending on results desired. Usually, carbon is added at one of the following points: (1) in raw water, (2) in mixing basin, (3) in treatment plants, (4) split feed, (5) in filters, and (6) with chlorine.

Copper sulfate is sometimes used at a surface water source where the tastes and odors are caused by small organisms living in the lake or reservoir. It may be applied by spraying a solution over the water surface or allowing crystals in a porous sack to dissolve. Because copper sulfate kills fish, its use is limited. Concentrations that kill common varieties of fish are listed below in pounds of copper sulfate per million gallons of soft water. Total concentrations are considerably higher in hard water.

Trout	1.2
Catfish	2.5
Suckers	2.5
Carp	2.5
Pickerel	3.5
Black Bass	17.0
Goldfish	4.0
Perch	6.0

Chlorine dosage at the plant of 0.3 to 1 ppm destroys most algae but may intesify tastes and odors. The break-point method of chlorination requires higher dosages but eliminates taste and odor as well as algae.

Potassium permanganate has shown great possibilities as a taste and odor treatment, and for serious problems, it is very economical. It does not combine with the substances causing taste and odor, but works as an oxidizing agent so there seems to be no possibility of intensifying or "setting" taste and odor. Experience indicates that permanganate is not a "cure-all." The residual manganese dioxide is insoluble, is absorbent, assists the coagulation process and is removed by coagulation and filtration. When the raw water carbon demand is 2 ppm or less, carbon is more economical than potassium permanganate.

Color Control

Color in natural waters is caused mainly by vegetable dyes or by excessive amounts of iron and manganese. Minerals contained in industrial wastes may also cause color. The coloration is usually caused by colloidal matter and may be removed in the same manner as other colloids, by chemical precipitation, coagulation or absorption, followed by filtration.

No one method will remove all colors and no rule will apply to all waters. Color removal requires trial of the following methods to determine which is most efficient and economical in the particular case.

Alum Coagulation. Coagulation with alum, followed by lime or soda ash if necessary, and filtration is the most common method. The alum must be added first and given some reaction time at a pH of 5.5 to 6.0 before adding the alkali. If the alkali is added first, it will "set" the colors and prevent removal.

Chlorination. Color removal by chlorination requires a dosage of 1.0 to 10.0 ppm, the correct amount being determined by trial. A detention or contact time of at least 15 minutes is necessary and not less than 0.1 free or combined residual should be maintained.

Chlorinated Copperas. The addition of chlorinated copperas at a low pH with an alum dose applied halfway through the coagulation basin has been very successful in some instances. Dosage has to be determined by trial.

Activated Carbon. Some color is susceptible to removal with activated carbon. The colloidal matter is absorbed by carbon atoms with free valences and is removed by sedimentation and filtration. Tests of carbon applied to the particular water is the only method of determining the effect of carbon for color removal.

EXERCISE III-2-2b

INSTRUCTIONS

Using your SG & AFR 91-26, complete the following statements.

1. Taste and odor can be controlled by ________________________ or by treatment with ______________ ______________, ______________ ______________ or ______________________.

2. Algae can cause unpleasant ______________________ and ______________________.

3. Color in natural waters is caused by ______________________ ____________ or by excessive amounts of ____________ and ________________________.

4. The principal cause of unpleasant taste and odor in water ____________ ________, ____________ ______________ and ______________ ______________.

5. ______________ ______________ gives water a rotten egg taste and odor.

SOFTENING

INFORMATION

Hard water may be potable, but it is objectionable because it deposits scale in pipes and boilers, leaves stains on glassware and kitchen utensils, and requires excessive amounts of soap to form lather. Rain water, in percolating down through the earth's formation and in flowing over the watershed, dissolves certain elements in the soil causing the water to become hard. Hardness results from the presence of calcium and magnesium compounds in solution in the water. Amount of hardness is sometimes rated as shown below.

Over 200 ppm	very hard
100 - 200 ppm	hard
50 - 100 ppm	moderately hard
below 50 ppm	soft
below 15 ppm	very soft

Many industrial processes are not able to use water containing an appreciable amount of hardness. There are two types of hardness, Carbonate (temporary) and Noncarbonate (permanent).

Carbonate Hardness

Carbonate hardness is caused by the combining in nature of calcium or magnesium carbonates with carbon dioxide to form calcium or magnesium bicarbonates. Calcium or magnesium bicarbonates cause "Temporary" or "Carbonate" hardness. It is called carbonate hardness because most of it is precipitated when the water is boiled, driving off the free and "half-bound" carbon dioxide, leaving the carbonates, which are insoluble.

Noncarbonated Hardness

Noncarbonate hardness, sometimes called permanent hardness, is due primarily to the sulfates of calcium and magnesium. The common name for calcium sulfate is "Gypsum," and of magnesium sulfate, "Epsom salts." The chlorides and nitrates of calcium and magnesium also form noncarbonate hardness but are not as common as sulfates. These compounds, causing noncarbonate hardness, are not precipitated by boiling.

NOTE: Iron and aluminum compounds also produce hardness, but usually is present in such small quantities that it is not generally associated with hardness. Water softening processes remove iron as well as calcium and magnesium salts.

Two chemical tests can be run to determine carbonate and noncarbonate hardness. These are the hardness test and the alkalinity test. If hardness is less than alkalinity, then all hardness of the carbonate type. If hardness is greater than alkalinity, then there is both carbonate and noncarbonate hardness present.

You can soften or reduce hardness by any method which can remove calcium and/or magnesium. Two major softening methods are used: (1) chemical precipitation, and (2) ion exhange. Most of the larger plants use the precipitation method; smaller municipalities and industrial plants are more likely to use ion exchange. Ion exchange method will be covered later.

Chemical Precipitation

Softening by chemical precipitation is accomplished by adding lime or lime and soda ash into the rapid mix. The lime reacts with soluble calcium and magnesium bicarbonates (carbonate hardness) to form insoluble calcium carbonate and magnesium hydroxide. You will recall that lime was listed as CaO (calcium oxide) or $Ca(OH)_2$ (calcium hydroxide). Remember, that calcium oxide added to water reacts to form calcium hydroxide, example $CaO + H_2O \longrightarrow Ca(OH)_2$.

Carbonate Hardness Removal is accomplished by adding lime to the water. The calcium hydroxide reacts with calcium and magnesium bicarbonates to form less soluble carbonates and hydroxides that precipitate out, leaving the water free of the substances causing carbonate hardness.

$Ca(HCO_3)_2$	+	$Ca(OH)_2 \longrightarrow$	$2CaCO_3$	+	$2H_2O$
Calcium Bicarbonate		Calcium hydroxide	Calcium carbonate percipitate		water

$Mg(HCO_3)_2$	+	$2Ca(OH)_2 \longrightarrow$	$Mg(OH)_2$	+	$2CaCO_3$	+	$2H_2O$
Magnesium bicarbonate		Calcium hydroxide	Magnesium hydroxide precipitate		Calcium carbonate precipitate		water

$$MgCO_3 + Ca(OH)_2 \longrightarrow CaCO_3 + Mg(OH)_2$$

Note that twice as much lime is needed to remove magnesium bicarbonate as calcium bicarbonate.

Noncarbonate Hardness Removal requires soda ash for calcium compounds and soda ash plus lime for magnesium compounds. This is illustrated in the following chemical reactions.

$CaSO_4$	+	$Na_2\ CO_3 \longrightarrow$	$Ca\ CO_3$	+	$Na_2\ SO_4$
Calcium sulfate		Sodium carbonate	Calcium carbonate precipitate		Sodium sulfate

$CaCl_2$	+	$Na_2\ CO_3 \longrightarrow$	$Ca\ CO_3$	+	$2NaCl$
Calcium chloride		Sodium carbonate	Calcium carbonate precipitate		Sodium chloride

$Ca(NO_3)_2$	+	$Na_2\ CO_3 \longrightarrow$	$CaCO_3$	+	$2NaNO_3$
Calcium nitrate		Sodium carbonate	Calcium carbonate percipitate		Sodium nitrate

The first step in reducing magnesium noncarbonate hardness is lime treatment.

$Mg\ SO_4$	+	$Ca(OH)_2 \longrightarrow$	$Mg(OH)_2$	+	$CaSO_4$
Magnesium sulfate		Calcium hydroxide	Magnesium hydroxide		calcium sulfate

Since the water contains $CaSO_4$, it is reduced by adding soda ash.

$Ca\ SO_4$	+	$Na_2\ CO_3 \longrightarrow$	$CaCO_3$	+	$Na_2\ SO_4$
Calcium sulfate		Sodium carbonate	Calcium carbonate		Sodium sulfate

$Mg\ Cl_2$	+	$Ca(OH)_2 \longrightarrow$	$Mg(OH)_2$	+	$CaCl_2$
Magnesium chloride		Calcium hydroxide	Magnesium hydroxide		Calcium chloride

then add Soda Ash

$CaCl_2$	+	$Na_2CO_3 \longrightarrow$	$CaCO_3$	+	$2Na\ Cl$
Calcium chloride		Sodium carbonate	Calcium carbonate		Sodium chloride

DETERMINATION OF DOSAGE. Quantitative analysis of the water is necessary for determination of required dosage of lime and soda ash.

It is well to check the calculations for lime and soda ash requirements by actually adding the calculated dosage to small measured quantities of the water to be treated. The following procedures may be used.

1. Prepare a standard lime suspension by adding ten grams of lime to one liter of boiled and cooled distilled water. If quick lime is used, shake it with just enough water to make a boiling solution, then dilute to one liter. A standard solution of soda ash is prepared in the same way. Adding one ml of the standard solution to one liter of water gives a dosage of ten ppm.

2. Place one liter of water to be treated in a beaker or jar and add calculated quantities of lime and soda ash needed to soften it. Stir gently for 30 minutes and allow to settle until liquid becomes fairly clear, usually 10 to 15 minutes.

3. Siphon off about half the clear solution, warm to about 120°F (49°C) and filter through filter paper.

4. Analyze filtrate for alkalinity in accordance with standard laboratory test procedure.

In the operation of a softening plant, it is customary to use lime in excess of computed needs to the extent of 10 to 50 ppm. This is then removed by recarbonation. After recarbonation and filtration, the water should have an alkalinity of approximately 35 ppm.

The quantity of noncarbonate hardness allowed to remain in the water is regulated by decreasing soda ash feed in accordance with the total hardness desired. If the total hardness in the softened water is to be 85 ppm and the alkalinity 35 ppm, it is then necessary to remove all but 50 ppm of noncarbonate hardness.

CHEMICAL FEEDING. Continuous softening requires application of chemicals in proportion to the rate of flow of water through the treating units. If the flow is constant over definite periods of time, the chemicals can be fed through constant-feed machines. If the flow is variable, proportioning devices in which chemicals are fed in suspension or solution are used.

Soda ash dissolves easily in water forming a clear stable solution. After preparation, the solution needs no further agitation and can be added directly to the water through a proportioning device.

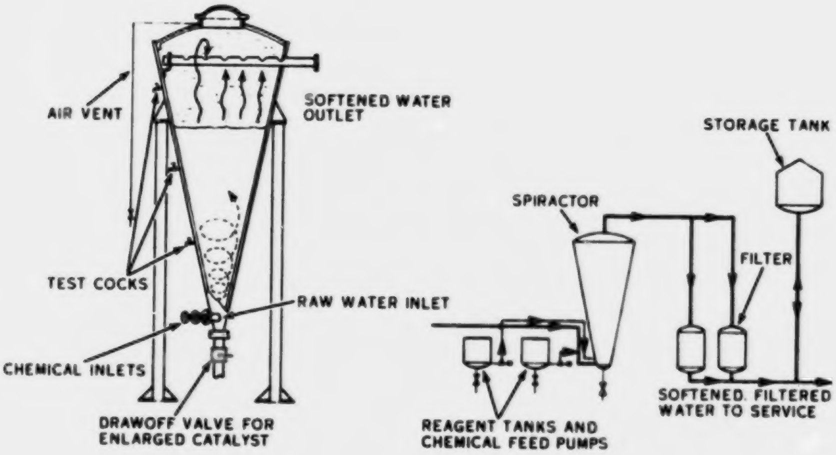
Lime, being only slightly soluble in water, forms a suspension known as milk of lime. Because suspended matter tends to settle, continuous agitation is necessary to keep the mixture uniform. Therefore, devices for feeding lime usually have mechanical agitators. Flow through feedlines must be fast enough to prevent lime from settling and clogging the lines. Long lines should be avoided or should be easily replaceable. They should have pressure connections for flushing. Rubber hose or open troughs are frequently used for this purpose.

Some plants feed lime and soda ash through one proportioning device. Chemicals are mixed in the proper proportions with water and introduced as a thin slurry. This method is satisfactory where the composition of raw water is constant or does not change rapidly.

Newer developments in softening include high rate equipment such as the precipitator, accelator, hydrotreater, and spiractor. The precipitator, accelator, and hydrotreater are also used as combined flocculation and sedimentation units without softening. When these units are operated before filtration to treat surface water with low suspended solids and low alkalinity, it may be necessary to add lime or clay to add weight and prevent rising floc. Wide fluctuation in flow, solids content, and temperature always cause operating problems which can best be corrected individually.

The accelator, precipitator, and hydrotreater operate on essentially the same principles.

The spiractor (see figure 2-12) consists of a cone shaped tank in which a lime soda softening process takes place in the presence of a suspended bed of granular calcium carbonate which acts as a catalyst. The hard water and the chemicals enter the bottom of the cone, where they mix and rise through the granular bed with a swirling movement. The upward movement of the water keeps the granular material in suspension. As the water rises, the velocity decreases to a point where the material is no longer in suspension. The contact time, 8 to 10 minutes, is enough to complete the softening process. The soft water is drawn off from the top of the cone. The hardness particles attach themselves to the calcium carbonate granules during the process and are withdrawn from the bottom of the cone. The advantages of this type equipment is its small size, low cost, fast treatment process, and the lack of moving parts and pumping equipment. In addition, the precipitated hardness is withdrawn as sand-like granules, which are much easier to dispose of than the watery slime from the normal lime-soda process. The unit is most effective when hardness is predominantly calcium; there is less than 17 ppm magnesium hardness; water temperature is about 50°F.; and turbidity is less than 5 ppm.


AIR VENT
SOFTENED WATER OUTLET
TEST COCKS
RAW WATER INLET
CHEMICAL INLETS
DRAWOFF VALVE FOR ENLARGED CATALYST
STORAGE TANK
SPIRACTOR
FILTER
REAGENT TANKS AND CHEMICAL FEED PUMPS
SOFTENED, FILTERED WATER TO SERVICE

SECTION OF SPIRACTOR

SYSTEM

Figure 2-13. Spiractor Softener

ACCELATOR. This cold lime-soda water softener is in use at some of the missile sites and at some of the Air Force bases. Since it has the capacity of softening large quantities of hard water containing calcium and magnesium salts, this section will cover the common types of cold lime-soda softeners, operation of the accelator, and the theory of operation.

There are four basic types of cold lime-soda softeners, namely: (1) the sludge-blanket type, (2) continuous sedimentation type, (3) the "catalyst type," and (4) the intermittent or batch-process type. The first three are continuous types; that is, the water is treated as it is flowing through the equipment. The fourth type is, as its name indicates, one in which the flow of water is not continuous but intermittent, as the water is treated in separate batches. Of these, the sludge-blanket type, owing to its higher efficiency, short detention period, and smaller space requirements, is rapidly displacing the conventional type for industrial use. It is also widely used in the municipal field, but some state boards of health prefer longer detention periods than the customary one-hour detention period in the sludge-blanket type. This continuous sedimentation type is an older type. The catalyst type produces a granular type of sludge which can be handled readily and which drains and dries rapidly.

SLUDGE BLANKET TYPE. This type differs from the sedimentation type in that the treated water is filtered upwardly through a suspended sludge blanket composed of previously formed precipitates. There are several distinct advantages obtained by this procedure. First, the upward filtration through the suspended sludge blanket results in the complete solution and use of the added lime. Second, the close contact of the treated water with a large mass of the sludge blanket prevents supersaturation. Third, the upward filtration in the sludge blanket results in the production of water which is clear enough without filtration for many industrial applications. Fourth, the detention period is much less for this type.

Figure 2-14 is a sketch of an accelator. In size, the vertical softeners may range from capacities of a few thousand to 10,000,000 gallons per day. Note that the outer chamber consists of a smaller conical or pyramidal section with its base more narrow than the top side. The raw water and the treating chemicals are introduced into the top of the inner chamber where they are thoroughly mixed by means of a centrally located mechanical agitator which is motor driven.

The chemical feeders used may be either of the wet or dry type, the latter type generally being employed only with the larger sizes of units. In the wet type of feeder, the hydrated or slaked lime is fed largely in the form of a suspension, usually of about a 5 percent concentration. Where soda ash is also required with the wet type of feeder, it is usually dissolved in and fed with the lime suspension instead of being fed separately. The coagulant is dissolved in and fed from a separate chemical feeder. When dry feeders are employed, separate feeders are used for the lime, the soda ash, and the coagulant.

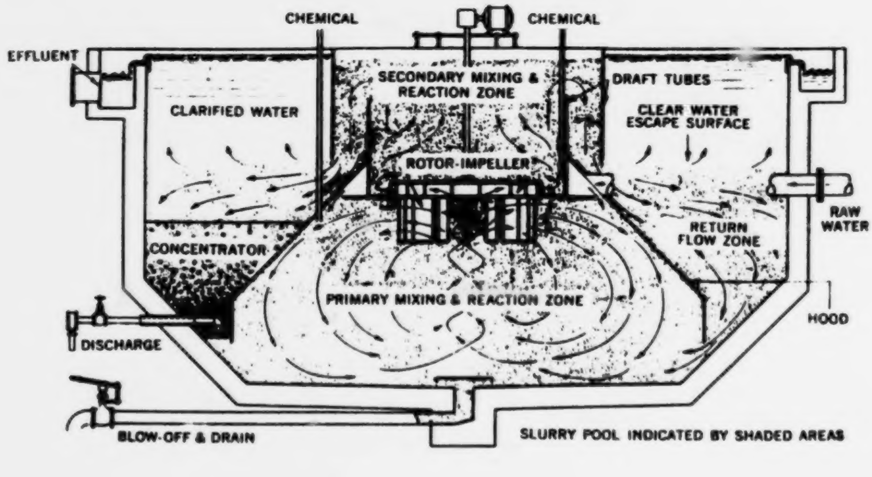

CHEMICAL
CHEMICAL
EFFLUENT
SECONDARY MIXING & REACTION ZONE
DRAFT TUBES
CLARIFIED WATER
CLEAR WATER ESCAPE SURFACE
ROTOR-IMPELLER
RAW WATER
RETURN FLOW ZONE
CONCENTRATOR
PRIMARY MIXING & REACTION ZONE
HOOD
DISCHARGE
BLOW-OFF & DRAIN
SLURRY POOL INDICATED BY SHADED AREAS

Figure 2-14. The Accelator (Upflow Clarifier)

The mechanical agitator consists of a series of paddles mounted on a vertical shaft, driven by a motor acting through a reducing gear. As the hardness in the water reacts with the added chemicals, the precipitates are produced which are kept in suspension by the agitator. The treated water, with its suspended precipitates, flows slowly to the bottom of the inner chamber and there, emerging from a series of openings, it reverses its flow and slowly rises in the outer chamber. Stilling baffles are sometimes used at the bottom to stop the rotary motion from being carried up in the outer chamber.

As the treated water rises in the outer chamber, its vertical velocity in the lower part of the chamber is sufficient to keep the precipitates in suspension. Owing to its design, the cross-sectional area of the outer chamber constantly increases while passing from the bottom to the top. The vertical velocity of the treated water constantly decreases during its passage through the outer chamber. Finally, a level is reached where, with a given volume of suspended sludge and for a given flow rate, it is unable to expand the sludge blanket, and in practice, there is a clear line between the upper level of the sludge blanket and the clear water rising above it which is collected by the collector system and then passes either directly to service or to the filters and then to service.

This upper sludge level is kept by bleeding off sludge at the same rate as that at which new sludge is being formed. This bleed-off can be done automatically. The bleeding-off operation is usually performed through an integral sludge concentrator. Increasing the flow rate will increase the height of the sludge blanket, and lowering the flow rate will decrease it. If the flow is lowered, the blanket contracts, but since the cross-sectional area decreases downwardly, the blanket is kept "alive" and functions just as efficiently. In general, the range over which types of equipment such as this will function satisfactorily is from 20 percent of the rated capacity, as the low limit, to about 110 percent, as the high limit.

CLARIFIER. The clarifier (figure 2-15) removes suspended matter and softens the water by the lime soda process. Water enters the clarifier at the top of the inner chamber and is flash mixed with the alkali and coagulant solutions. The alkali reacts to precipitate the hardness, and regulate the pH for best coagulation. The coagulant reacts with the added alkalinity to form a floc which tends to increase in size and settle towards the bottom. Slowly revolving agitator blades, at the bottom and at the center of the inner chamber, gently mix the floc and the water. This operation further increases the floc size as particles of suspended matter and precipitated hardness are caught by the floc. Clear water rises in the outer chamber and the heavy floc tends to remain in the lower portion of the outer chamber. Clear water flows through a distributor in the top of the outer chamber into a clearwell. A pump pumps the clear water from the clearwell. Over a period of time, floc tends to build up in the outer chamber. The desludging timer should be adjusted to maintain the floc blanket just below the third sampling clock from the bottom. If the floc is very slow settling, it may be necessary to blow down more frequently to prevent the carry over of floc into the clearwell.

Proper operation of the clarifier is dependent upon the following factors:

a. Raw water quality
b. Water temperature
c. Coagulant and alkali feed rates
d. Type of coagulant and alkali used
e. Raw water flow rate

The alkali used must precipitate enough of the hardness to reduce the total hardness of the clarified effluent to 200 to 300 ppm. Three possible alkalies, (soda ash, lime soda, or caustic soda) may be used. Soda ash removes the noncarbonate hardness. The lime and caustic soda remove the carbonate hardness. Soda ash, which will remove additional noncarbonate hardness, is formed also by the reaction of caustic soda with the carbonate hardness. Because of the acid treatment before the degasifier, the water entering the clarifier has essentially no carbonate hardness. The majority of the alkali solution must be soda ash. A certain amount of carbonate hardness will form when the soda ash is added. For this reason either lime or caustic soda must be used to precipitate the carbonate hardness. The optimum alkali solution is the solution which will allow the reduction of the hardness to 200 to 300 ppm as $CaCO_3$ and still prevent the rise of the effluent pH above the 9.0 to 9.5 range. It is in this pH range that the solubility of calcium carbonate is lowest and maximum softening will result.

The coagulant used and the coagulant feed rate will be largely determined by the pH of the clarified water, jar test results, and chemical cost. There are several coagulants that may be used. Some of these are alum (aluminum sulfate), ferrous sulfate, ferric sulfate or ferric chloride. Alum generally coagulates best in the pH range of 5.5 to 8.0. Ferrous sulfate coagulates best in the pH range of 8.5 to 11.0. The ferric coagulants coagulate over a wide pH range of 4.0 to 11.0.

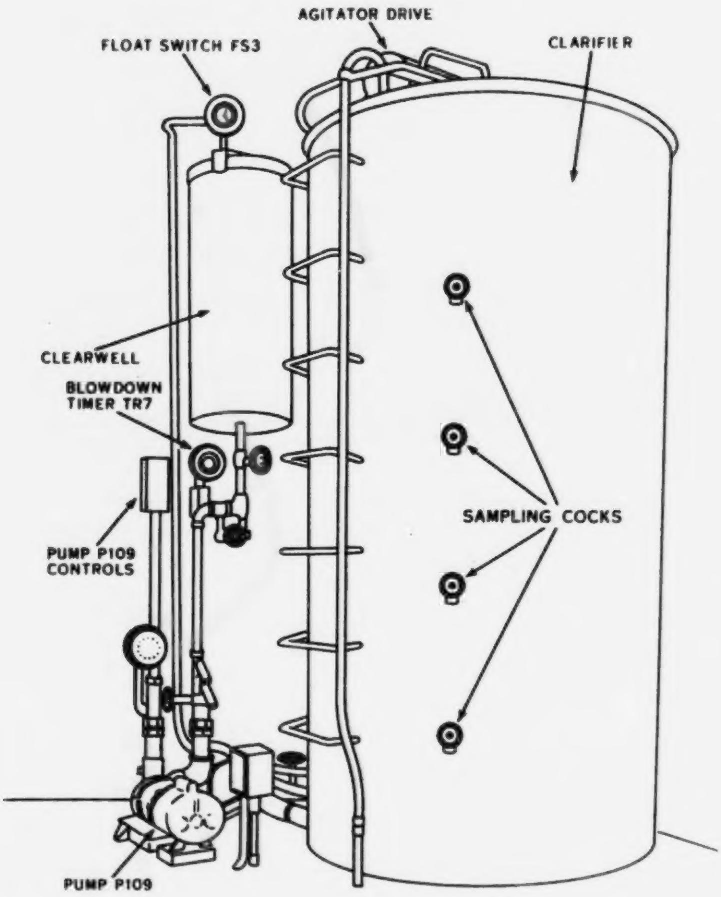

AGITATOR DRIVE
FLOAT SWITCH FS3
CLARIFIER
CLEARWELL
BLOWDOWN TIMER TR7
SAMPLING COCKS
PUMP P109 CONTROLS
PUMP P109

Figure 2-15. Clarifier Assembly

CLARIFIER CONTROLS. The agitator drive on the clarifier is controlled by a manual motor starter. Because the agitator drive must be operated continuously (even when the well pump is not operating), it is not controlled by the relay in the well pump controls. The blowdown timer is controlled by contacts in the well pump controls. These contacts close to energize a timer five seconds after the well pump starts. As the timer runs, it periodically closes contacts to energize the blowdown solenoid valve. The timer is adjusted to blow down the clarifier often enough to prevent the carryover of floc into the clearwell.

Electrical controls for the pump are set as follows: The selector switch is placed in an automatic position. The manual motor starter is placed in the ON position. Then the results are as indicated. The pump motor is energized if the contacts on the float switch are closed. The float switch is located in the clarifier clearwell and controls the pump to prevent the pump from pumping the clearwell dry. The pump may be started independent of the float switch, by positioning the selector switch to the hand position. This type operation is only for clarifiers shown in Figure 2-15.

EXERCISE III-2-2c

INSTRUCTIONS

Complete the following questions. You can consult your instructor if you have any questions.

1. What are the two types of hardness?

   ____

2. What are the two major softening methods?

   ____

   ____

3. Lime is added to water to reduce ______________ hardness.

4. Lime and soda ash are added to the water to reduce ______________ hardness.

5. Water that is free of Ca $(HCO_3)2$ and Mg SO_4 is said to be ______________ water.

6. What type of high rate softening equipment uses the sludge blanket principles of operation? ______________________________

   ____

7. What chemical tests can be run to determine carbonate and non-carbonate hardness?

   ____

   ____

STABILIZATION

INFORMATION

Need for Stabilization

Production of an acceptable water does not end with disinfection, clarification, and filtration. Water furnished for consumption must neither scale nor corrode the distribution system. The processes of coagulation and softening previously described do not, as a rule, produce a water that will meet these requirements. The pH, alkalinity and hardness may be so low and the carbon dioxide (CO_2) so high that the calcium carbonate will scale mains, meters, and hot water heaters. To avoid these circumstances, water may be first supersaturated as to calcium carbonate content, in which condition a protective film against corrosion will deposit on pipe walls; then, an equilibrium point of the water is sought such that it will neither dissolve nor deposit calcium carbonate. Under these conditions a protective coating of calcium carbonate lining pipe walls will be undisturbed, thus preventing corrosion of the metal underneath, and progressive scaling will not occur.

The adjustment of pH and alkalinity of a water to a calcium carbonate saturation-equilibrium value is known as stabilization. The pH associated calcium carbonate equilibrium may either be calculated or determined by the calcium carbonate stability test. A formula developed by Langelier forms the basis of calculations for pH saturation values (Table 2). For routine chemical control the calcium carbonate stability test offers a simple and direct indication of the equilibrium of calcium carbonate in the water. A modification of the marble test, known as McLaughlin's "Marble Test" Graph, will be found useful in the calculation of lime dosages for pH correction.

Stabilization of Lime Softened Waters

Lime softened water may not be stable because of the high content of calcium and magnesium carbonates. If the excess is not removed, scale is deposited in the distribution system, hot water heaters, meters, and the like. Encrusting of filter sand and gravel is also experienced.

Lime softened water can be stabilized by recarbonating with carbon dioxide gas. After the water has passed through the settling basins but before it has reached the filter, carbon dioxide is diffused into the water through small openings in a grid system. The carbonic acid formed by the gas in solution neutralizes excess alkalinity in the water and converts slightly soluble excess lime and carbonates to highly soluble bicarbonates. Bicarbonates do not precipitate from water easily so scale formation is prevented. Excessive recarbonation can produce a corrosive water, if carbonic acid (free CO_2) remains after completion of the reaction.

Lime softened water can also be stabilized with sulphuric acid. Because calcium sulphate is formed by the reaction, close control of dosage is necessary to avoid formation of excess amounts of noncarbonate hardness. Base the dosage on laboratory scale treatment and alkalinity test.

Most of the scale formed in water systems is similar in appearance; however, there are several distinct types of scale. Among the most common are (1) pure mineral scale, (2) mixed scale and corrosion products, and (3) combination of minerals.

1. Pure mineral scale, such as $CaCO_3$ and $CaSO_4$. Calcium carbonate forms a loose sludge-like deposit that will crumble rather easily when dried. Calcium sulfate forms a hard adherent type of scale which is especially objectionable in boilers.

2. Mixed scale and corrosion products. Hot water pipes are often found containing layers of rust sandwiched in between layers of mineral scale.

3. Combinations of minerals cemented together by binders, such as silica. Such combinations will produce a hard "baked-on" type of scale on hot boiler surfaces.

Scale is an undesirable formation, having the following adverse effects:

1. Reduces the safety factors by clogging the safety valves and gauge lines.

2. Clogs pipes, thus reducing carrying capacity. Pipes should be cleaned, if possible, rather than replaced. Once the scale has been removed, a chemical treatment should be used to prevent new formation.

3. Reduces operating efficiency of heating and cooling systems by clogging coils, heat exchangers, and radiators.

4. Reduces rate of heat transfer in boilers.

5. Increases cost of operation by adding to cost of maintenance and replacement.

The treatment used to clarify water may result in a very sparkling product and yet be a heavy scale maker.

In the cold lime process of clarification, water is softened by chemical reaction. This reduces the scale forming hardness minerals thereby protecting the distribution system from severe scaling. Any process that will reduce hardness will reduce scale.

Scale can be formed by several different compounds but distribution lines are most commonly found to contain calcium carbonate and calcium sulfate.

Besides using softened water, another method of preventing scale formation is the addition of polyphosphates. Polyphosphates will prevent the hardness minerals from coming out of solution to form the scale and also stop the chemical reaction of lime softening so it will not precipitate out in the distribution lines.

Corrosion or rust is always a problem in water lines and can, if conditions are right, completely destroy a water line in one year or less. Corrosion inside a water pipe is difficult to detect and major damage can occur before it is found.

When water has a low pH (below 7) corrosion can occur rapidly. The remedy is to raise the pH of the water by adding chemicals that will add alkalinity to the water such as sodium hydroxide (lye). If the water is treated in a lime-soda plant it also will cause the pH to rise above a corrosive level.

Many water plants add small amounts of phosphate compounds to prevent pipeline corrosion. Phosphates will form a very thin film on the inside walls of pipes and so prevent moisture and oxygen from attacking the iron.

When water is to be used commercially, such as in boilers or cooling towers, then strong doses of corrosion preventatives can be added but domestic water must be only lightly treated and then only with chemicals that are not poisonous.

DISINFECTION

Disinfection is a necessary step in the insuring of a safe water supply. It is almost impossible to secure a natural water supply free of bacteria and impurities. Therefore, man must treat and disinfect his water supply before he can drink it without risk. The most commonly used disinfectant is chlorine. It is the disinfectant normally specified for Air Force use. Disinfection is the process of destroying disease producing organisms. There is also the possibility of water becoming recontaminated from handling before consumption. Therefore, a slight chlorine residual is provided for after purification to combat secondary contamination.

This information will be discussed under the following main topics:

- Need for Disinfection
- Chemicals Used
- Types of Treatment
- Chlorination Equipment
- Chlorination Controls
- Chlorination Operation and Safety Precautions

Need for Disinfection

People with the problem of supplying satisfactory water to a single family or to a city must meet the rigid specifications placed upon this service by the consumer. These specifications require the water to be safe, free from tastes and odors, clean, cheap, and in abundant supply.

The clear, cool spring water of past years which was pure and uncontaminated represents the water supply that must be duplicated today to meet the needs of the consumer. Unfortunately, nature does not provide pure water supplies sufficient for all needs. It is necessary, therefore, to make the supplies we have meet our requirements. Contaminated water must be made free of disease bearing organisms. Hard water must be made soft. Cloudy water must be made clear. Tastes and odors must be removed. All of these things must be done inexpensively so that all may have the finished product in abundance. Man is fortunate in having various means of purifying water supplies, the main one being chlorination.

The beneficial effects of chlorination upon the general health of our nation is almost unbelievable. Water-borne disease including typhoid fever was very common before chlorination but is rarely encountered today. Whether applied as hypochlorite or chlorine, the chlorination of water is the most important treatment used to make raw water potable.

In this day, when man's interests carry him both far and near, no water supply may be considered entirely safe without chlorination. The most remote reservoir may be contaminated overnight by a careless camper. Shallow wells may easily be contaminated by polluted surface water. Deep wells may be contaminated at any time by polluted water through a break in the casing or the opening of a lead to a polluted stream previously not connected. All raw water, from the clearest and purest to the most turbid, should be chlorinated before being used for human consumption.

Chemicals Used

Chlorine is the disinfectant normally specified for Air Force use. It is presently the only widely accepted agent that destroys organisms in water and leaves an easily detectable residual that serves as a tracer element. Its sudden disappearance may signal contamination in the system. Under ordinary temperatures and pressures, chlorine is a greenish yellow gas that is 2.5 times heavier than air. Its activity as a disinfectant depends on the temperature and pH of the water to which it is added. Disinfecting action is faster at higher temperatures, but is retarded by high pH. If the pH is above 8.4, the rate of disinfection decreases sharply. Chlorine may also be used to control tastes and odors, nuisance bacteria, remove iron, and assist in coagulation.

LIQUID CHLORINE. Liquid chlorine is a liquefied gas. It is under pressure and is shipped in seamless steel cylinders under Interstate Commerce Commission regulations. The gas has a strong, pungent odor. The liquid is a clear amber color. In a moisture free state, it is relatively noncorrosive. In the presence of moisture, it is highly corrosive, and is an irritant to the respiratory system and the skin. The standard sizes of shipping containers are the 150-pound cylinder and the one ton container.

Each pound of liquid chlorine produces about five cubic feet of chlorine gas at atmospheric pressure and a temperature of 68°F. A standard chlorine institute valve and a protective valve hood are screwed into the neck of each cylinder. The valve has a safety plug of a metal that softens between 157° and 162°F., this protects the cylinder from bursting in case of fire. All cylinders must be factory tested every five years; 150-pound cylinders are tested at 500 pounds of pressure, one-ton containers at 800 pounds of pressure.

CALCIUM HYPOCHLORITE. Calcium hypochlorite, $Ca(OCl)_2$ is a relatively stable, dry, granule or powder in which the chlorine is readily soluble, and is sold under a number of trade names including HTH, Perchloron, and Hoodchlor. It is furnished in three to 100-pound containers and has 65 to 70 percent of available chlorine by weight. Because of its concentrated form and ease of handling, calcium hypochlorite is preferred over other hypochlorites.

SODIUM HYPOCHLORITE. Sodium Hypochlorite, NaOCl, is generally furnished as a solution that is highly alkaline and, therefore, reasonably stable. Federal specifications call for solutions having five and ten percent available chlorine by weight. Shipping costs limit its use to areas where it is available locally. It is also furnished as powder under various names such as Lobax and HTH-15. The powder generally consists of calcium hypochlorite and soda ash, which react in water to form sodium hypochlorite.

CALCIUM HYPOCHLORIDE. Calcium Hypochloride, also known as chloride of lime and bleaching powder, is a low-grade calcium hypochlorite testing about 35 percent available chlorine when fresh. However, it deteriorates rapidly in hot moist atmosphere and should, therefore, be purchased in small packages that can be kept effectively sealed. Calcium hypochloride contains an excess of insoluble lime, hence, solutions should be prepared in a separate container, the lime permitted to settle, and the liquid decanted into a separate tank for use.

CHLORINE DIOXIDE. Chlorine dioxide, ClO_2, is produced by adding sodium chlorite solution at the discharge end of a gas chlorinator and running the mixture through a small contact chamber before introducing it into the water. It has 21.5 times the oxidizing power of chlorine and is effective in taste and odor control. Experiments indicate that it may be a better bactericide than chlorine in nonpolluted waters where it is not used up in oxidation before its bactericidal action can take place.

MISCELLANEOUS: Miscellaneous purification methods and agents are as follows:

o Water may be disinfected by boiling vigorously for two or three minutes.

o Ozone released in water from atmospheric oxygen will act as disinfectant. The ozone is produced from dry air by an electric discharge. It is only slightly soluble in water and requires a thorough mixing to be effective.

o Ultraviolet ray may be utilized as a disinfectant. In this method, the water flows in a thin stream past or around special lamps which give off ultraviolet rays. The rays are ineffective in colored or turbid waters.

o Halazone or iodine tablets may be used for emergency or field disinfection of water in small quantities. These tablets are used one or two to a canteen of water.

o Lime is used quite extensively in water softening plants and it will also disinfect the water. Its use has been restricted to commercial plants because of the skilled operation required to give satisfactory results.

o Potassium permanganate and silver may also be used as disinfectants.

REACTIONS. When chlorine is introduced into pure water, it reacts to form hypochlorous acid, HOCl, and hydrochloric acid, HCl.

Chlorine disinfectants are available in a number of different forms. For procurement see AFM 67-1.

Cl_2 and H_2O ——> HOCl and HCl

The chlorine ion of the hydrochloric acid does not contribute to purification reactions. It is the hypochlorous acid which actually kills microbial organisms present in water. Some may remain in molecular solution as Cl_2. These forms of chlorine are termed free available chlorine, since their oxidizing and disinfecting ability are fully available. However, most natural waters contain small amounts of ammonia and nitrogenous organic substances. Free available chlorine reacts with these to form chloramines, such as NH_2Cl, and other complex chlorine-nitrogen compounds. These forms are termed combined chlorine, since part of the oxidizing and disinfecting ability of the chlorine is lost. Both free available and combined chlorine further react with substances in the water until their oxidizing and disinfecting ability is depleted. The amount of chlorine required to react with these substances in a given time, usually ten minutes, is called the chlorine demand. Chlorine remaining in excess of the chlorine demand is the total chlorine residual, or residual chlorine. This is composed of both free available and combined chlorine, as determined by the orthotolidine test; the two forms are differentiated by the orthotolidine-arsenite or OTA test. The time elapsing between the introduction of chlorine and the use of the water is termed the contact period.

Definitions

(1) Residual chlorine is the term which is applied to the available chlorine which remains after the chlorine demand (amount of chlorine required to destroy bacteria and organic matter) has been satisfied. Presence of residual chlorine in a water supply is insurance against non-contamination. At fixed installations, a chlorine residual content of 0.4 ppm is required at all times.

(2) Free available chlorine. Refers to the chlorine present in solution as hypochlorous acid and hypochlorite ion present in the water. These are the most effective disinfecting forms of chlorine. The relative amount of each present in the water is dependent upon the pH value of the water. It is important to remember that when the pH is raised, the quantity of free available chlorine required to kill the same number of micro-organisms increases. With a decrease in temperature an increase of dosage is required to maintain the same number of micro-organisms killed.

(3) Combined available chlorine. The chlorine present in water which reacts with ammonia or nitrogen to form chloramines.

(4) Total available residual chlorine is the sum of free available chlorine and the combined available chlorine.

(5) Chlorine dosage. Dosage is the amount of chlorine added to water to satisfy the chlorine demand as well as to provide a residual after a specified time. The dosage is usually stated in terms of parts per million (PPM).

(6) Chlorine demand. Demand is the amount of chlorine which reacts with chlorine-consuming agents in a specific amount of time. Chlorine demand varies with the nature and quantity of chlorine-consuming agents, the pH value and the temperature of the water, and the contact period.

(7) Disinfecting time. Chlorine demand in most water is virtually satisfied ten minutes after chlorine is added. When one PPM chlorine residual remains after the ten-minute period, satisfactory disinfecting action usually results after an additional 20 minutes of contact.

Effectiveness

(1) Chlorine residual. Effectiveness increases rapidly with increase in residual. However, free available chlorine is much more effective than combined chlorine, so that the relative amount of each in the total residual is important.

(2) Contact period. The required contact period is inversely proportional to residual, within normal limits. Thus, if the residual is halved, the required contact period is doubled.

(3) Temperature. Effectiveness at 35° to 40°F. is half of that at 70° to 75°F.

(4) pH. Effectiveness is highest at pH below 7.0. At pH 8.0, it is half and at pH 9.0, it is one-fourth to one-sixth as effective as at pH 7.0.

(5) Points of application. Plain or simple chlorination is the single application of chlorine to unfiltered supplies before discharge into the distribution system, as for example, the chlorination of ground water supplies and previously unchlorinated purchased supplies. Prechlorination is the application of chlorine to raw water before coagulation, sedimentation, and filtration. Postchlorination is the application after filtration but before the water leaves the treatment plant. Rechlorination is the application at points in the distribution system or to a previously chlorinated purchased supply to maintain the chlorine residual. The above applications are normally continuous. Very heavy chlorination for a limited period is applied at specific points of the distribution system to destroy localized contamination.

Areas Requiring Special Treatment

AMOEBIC CYSTS. Amoebic cysts are best removed by diatomite filtration preceded by adequate coagulation and settling. When this is not possible, water suspected of containing cysts, if moderately clear with pH of 7 or less, can be disinfected by adding enough chlorine to produce a residual slightly greater than 2 PPM after a 30-minute contact period.

When schistosomiasis is a problem and diatomite filters are not available, reasonable protection can be obtained by adding enough chlorine to produce a residual of one PPM after 30 minutes contact.

SWIMMING POOLS. Maintaining a safe chlorine residual in swimming pool water is even more important than maintaining it in drinking water. This is because drinking water is protected, while swimming pool water is constantly contaminated by the bathers. Water spit out by one bather may quickly be swallowed by another. The length of time the chlorine has to act may be very short. Hence, chlorine residuals must be kept very high. At all Air Force swimming pools, the free available chlorine residual shall be maintained between 0.4 and 0.6 PPM. In addition to killing bacteria rapidly, this level of chlorine residual will prevent the growth of algae.

DISINFECTING SYSTEM COMPONENTS. Water mains, wells, filters, storage tanks, and other units of a water supply system become contaminated during construction and repair. Flushing the system to remove dirt, waste, and surface water which is introduced is the first step, but is not a sufficient safegard. To insure a safe water supply, each unit of the system must be thoroughly disinfected before it is placed in operation.

The chemicals used in disinfecting a water system are the same as those used in disinfecting the water. Hypochlorite solution or chlorine gas are most commonly used.

Chlorine dosage required to disinfect any unit thoroughly depends on contact time, and the presence of organic chlorine consuming material such as the jute used in pipe joints. Under average conditions the following minimum dosages are recommended.

Unit	Dosage (PPM)
Pipe	50
Storage Tank	50
Filter	100
Well	150

The volume of water in the unit to be disinfected must be computed before chlorine dosage can be estimated.

Types of Treatment

MARGINAL CHLORINATION. Marginal chlorination is the application of chlorine to produce the desired total chlorine residual without reference to the relative amounts of free available and combined chlorine present. It is so termed because the initial chlorine demand has been satisfied, but some oxidizable substances remain; it is the usual type of chlorination. Its bactericidal effectiveness is not predictable within close limits.

CHLORINE-AMMONIA TREATMENT. Chlorine-ammonia treatment consists of adding both ammonia and chlorine to form chloramines. This compound provides a persistent chlorine residual and reduces any unpleasant chlorine taste. Chloramine reacts so slowly that a very long contact period is needed for complete destruction of microorganisms. To reduce this, chlorine may be applied first, and after the shorter contact period necessary for the bacterial kill, the ammonia is introduced. With proper chlorine-ammonia dosages the chloramine residual is usually two to four times greater than those normally carried in marginal chlorination.

BREAK-POINT CHLORINATION. Break-point chlorination is the application of chlorine to produce a residual of free available chlorine, with no combined chlorine present. As chlorine is added, the total residual increases gradually after the initial demand of the water has been satisfied. At some residual concentration, depending on the nature of the water treated, free available chlorine reacts with any remaining oxidizable substances, including combined chlorine, and the residual drops sharply. When all combined chlorine has been oxidized by reaction with free available chlorine, the residual, now consisting only of free available chlorine rises again and continues to increase in direct proportion to increased dosage. The point at which the residual again begins to increase is the breat point, you can see this in figure 27. Advantages of break point chlorination are high bactericidal efficiency, long lasting residuals, and low taste and odor characteristics. The application of break point chlorination procedure before instead of after filtration has been found to be desirable.

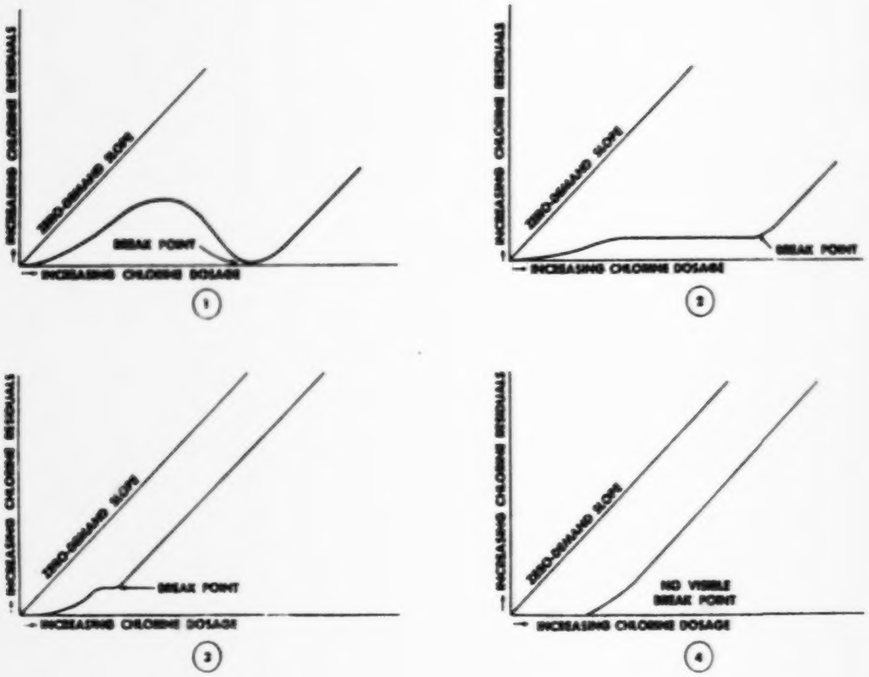


Figure 2-16. Break-Point Chlorination Curves

SUPERCHLORINATION. Superchlorination is the application of more chlorine than needed for the chlorine residual essential to marginal chlorination; this is done to control tastes and odors. This method is particularly valuable in surface water with variable ammonia and organic content. The surplus chlorine is later removed by aeration or by a dechlorinating agent such as sulphur dioxide or activated carbon. Sulphur dioxide reacts with chlorine to form acids which are neutralized by the natural alkalinity of the water. It is fed by equipment similar to that used for chlorine feeding. Activated carbon absorbs excess chlorine and is removed by settling or filtration; aeration removes excess chlorine by dissipation to the atmosphere.

Chlorination Equipment

Chlorination equipment to feed chlorine gas or hypochlorite solution is of three general types, depending on methods of control. In the manually controlled type, equipment must be started and stopped manually, and rate of feed must be manually adjusted to rate of water flow. In the semiautomatic type, equipment starts and stops automatically as water flow starts and stops, but must be manually adjusted to rate of water flow. This type is normally used with a water pump having fairly uniform delivery. In the fully automatic type, rate of feed is automatically adjusted to rate of flow of water being treated. The differential pressure of a metering device is used to accomplish this. In all types, the ratio of feed to water treated, or dosage, is set by manual adjustment. Chlorinators may also be classified generally as direct feed and solution feed. Direct-feed machines are designed to operate without a pressure water supply, feeding the chlorine gas directly to the flow to be treated. Solution-feed machines dissolve the gas in a minor flow of water and inject the resultant solution into the flow to be treated. They require a pressure water supply for operation. Chlorinators are also classified by the type of diaphragm used in controllling the chlorine feed. There are two types, the water diaphragm and the mechanical diaphragm. The water diaphragm machine is always vacuum type, solution feed machine and has the advantages of a friction free, puncture-proof water diaphragm. The mechanical diaphragm machine may be either direct or solution-feed vacuum type only.

DIRECT FEED CHLORINATORS. Direct feed chlorinators are used chiefly as emergency equipment and on small installations where it is not possible to obtain a water supply suitable for operating a solution feed machine. They cannot be used where the pressure of the water being treated is more than 20 p.s.i. and are limited in the types of semiautomatic or automatic controls which may be used. Due to chlorine being under pressure as a gas at all times, direct feed machines are highly susceptible to leakage of the gas to the atmosphere with resultant corrosive action on adjacent equipment and structures.

SOLUTION FEED CHLORINATORS. Solution feed chlorinators introduce chlorine gas into the water supply by means of a chlorine solution usually formed by drawing chlorine gas into the jet stream of water at the low pressure point of an injector mechanism of the chlorinator. Two general types are used in the water works, the bubbling or pulsating reduced pressure type and the vacuum type. Because they keep the chlorine under a partial vacuum, they cause fewer chlorine leaks than pressure gas chlorinators and direct diffusers.

Vacuum Type, Water Diaphragm Chlorinator manufactured by Wallace and Tiernan, Inc. (See figures 2-17 and 2-18.)

This type machine has a bell jar set in a tray of water which acts as the water diaphragm. A small quantity of water is constantly supplied to the tray to maintain the bell seal and the excess overflows to the waste. In some machines this water is supplied through a constant level box with float-controlled make-up valve. The main elements of this chlorinator are the injectors through which a water supply flows, the chlorine control valve, and the orifice meter. The injector creates a partial vacuum within the bell jar causing the water level to rise inside the jar. Chlorine gas passes from the chlorine cylinder through the chlorine pressure reducing valve and into the bell jar. The pressure reducing valve is located inside the bell jar and is controlled by a ball float which moves with the surface of the water within the bell jar. This inside water surface acts as a diaphragm which, when it lowers, causes the float-controlled valve to reduce the chlorine flow into the bell jar, and conversely, to increase the chlorine flow when the water level rises.

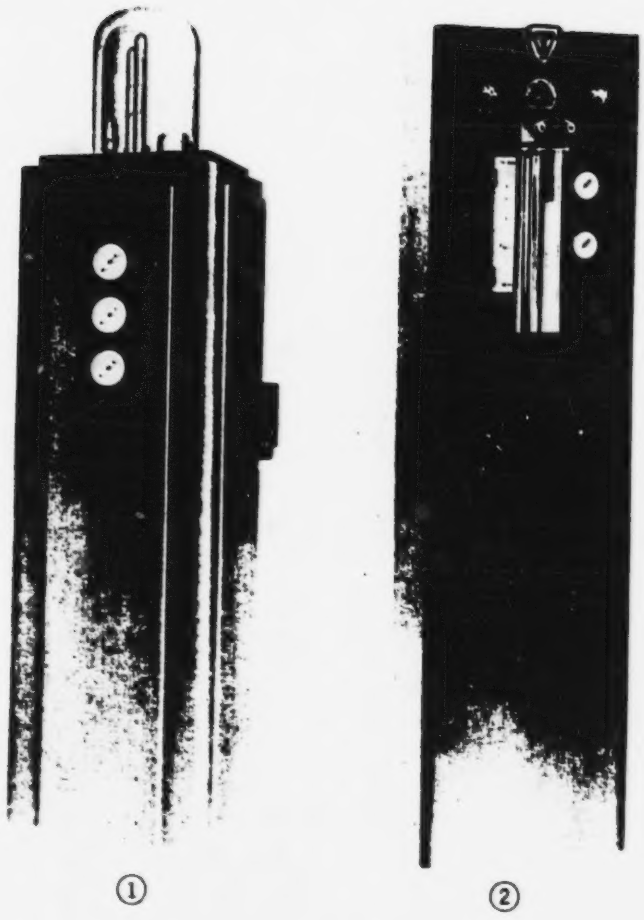


Figure 2-17. Views of Vacuum Type Chlorinators: (1) Water Diaphragm; (2) Mechanical Diaphragm

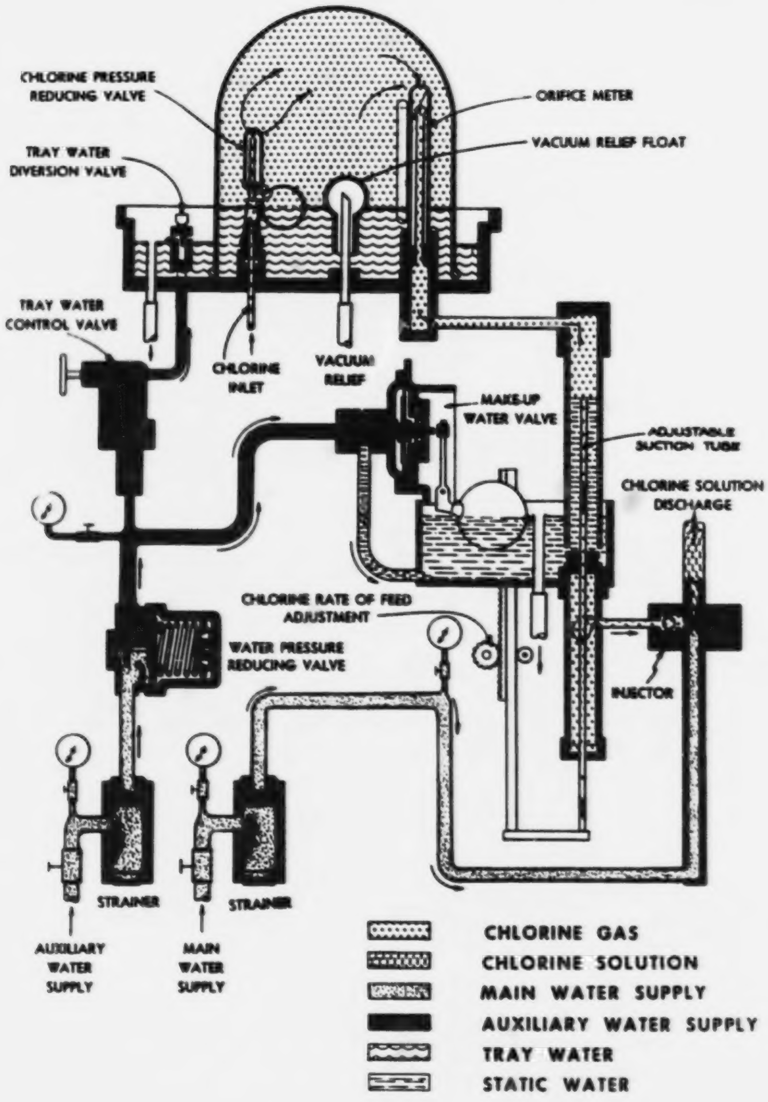

CHLORINE PRESSURE REDUCING VALVE
ORIFICE METER
VACUUM RELIEF FLOAT
TRAY WATER DIVERSION VALVE
TRAY WATER CONTROL VALVE
CHLORINE INLET
VACUUM RELIEF
MAKE-UP WATER VALVE
ADJUSTABLE SUCTION TUBE
CHLORINE SOLUTION DISCHARGE
CHLORINE RATE OF FEED ADJUSTMENT
WATER PRESSURE REDUCING VALVE
INJECTOR
STRAINER
STRAINER
AUXILIARY WATER SUPPLY
MAIN WATER SUPPLY
CHLORINE GAS
CHLORINE SOLUTION
MAIN WATER SUPPLY
AUXILIARY WATER SUPPLY
TRAY WATER
STATIC WATER

Figure 2-18. Flow Diagram of Vacuum Type Chlorinator-Water Diaphragm

Vacuum Type, Mechanical Diaphragm Chlorinator Manufactured by Wallace and Tiernan, Inc. (See Figure 2-19).

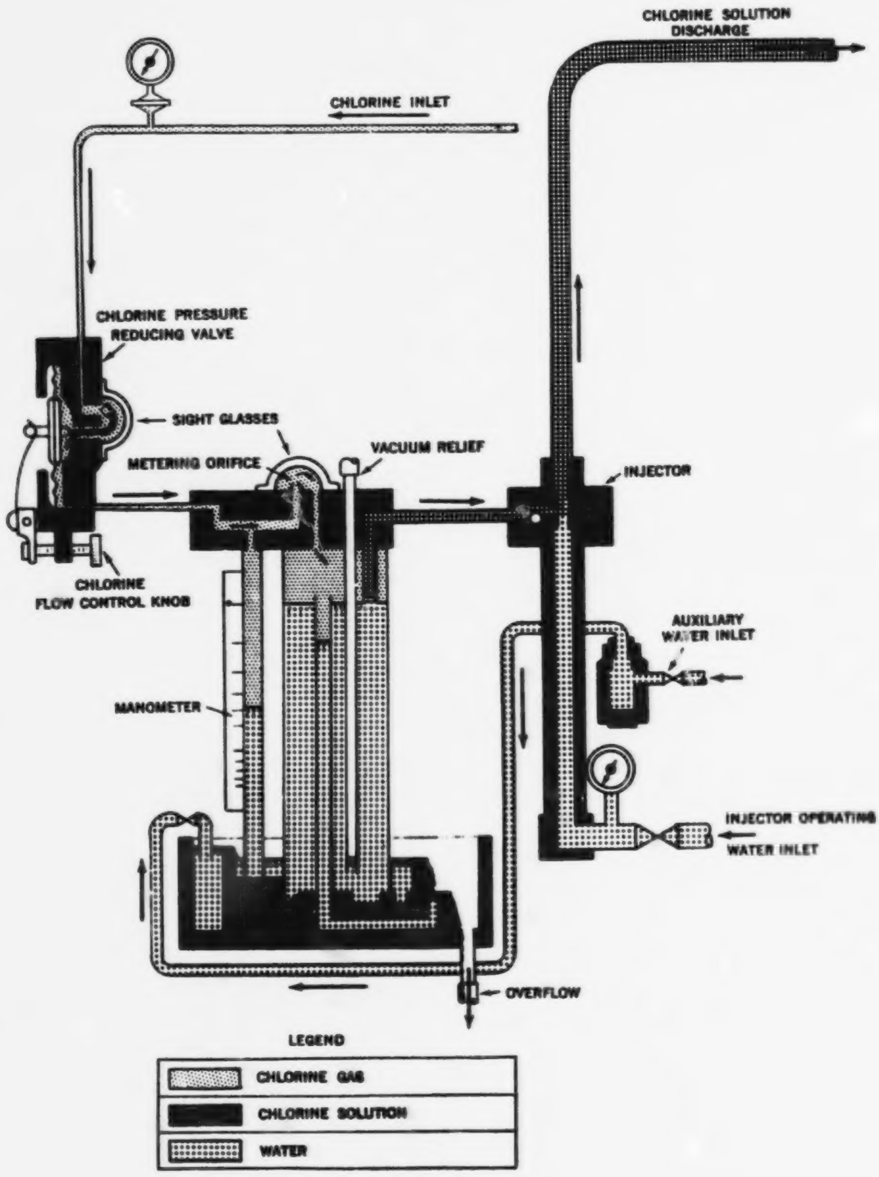

CHLORINE SOLUTION DISCHARGE
CHLORINE INLET
CHLORINE PRESSURE REDUCING VALVE
SIGHT GLASSES
VACUUM RELIEF
METERING ORIFICE
INJECTOR
CHLORINE FLOW CONTROL KNOB
AUXILIARY WATER INLET
MANOMETER
INJECTOR OPERATING WATER INLET
OVERFLOW
LEGEND
CHLORINE GAS
CHLORINE SOLUTION
WATER

Figure 2-19. Flow Diagram of Vacuum Type Chlorinator-Mechanical Diaphragm

The bell jar is also provided with a vacuum relief valve to admit air when the chlorine supply is exhausted or fails and the water level in the jar rises. The metering orifice is also located inside the bell jar and above the water level. It controls the flow of chlorine gas to the injector where it is mixed with water to form a chlorine solution which is then mixed with water to be treated. Rate of feed is proportional to the negative pressure difference between the bell jar and meter. The amount of vacuum within the meter is controlled by the height of the adjustable suction tube, and is indicated by the rise of water in the annular space within the glass meter tube. A scale mounted on the metering tube indicates the rate of chlorine feed in pounds per 24 hours. This machine can be equipped for manual, semiautomatic or automatic operation.

The chlorine control valve and compensator are of the needle and differential diaphragm type. Gas pressure is reduced by this combination valve and compensator before metering and it maintains a constant pressure of chlorine gas against the metering orifice. The metered flow of chlorine gas is passed through the meter to the injector where it is mixed with water and the resulting chlorine solution is then mixed with the water to be treated. A vacuum relief valve is provided at the metering orifice chamber, which admits air should the chlorine gas supply become exhausted or fail. Equipment for manual, semiautomatic, or automatic operation is optional.

HYPOCHLORINATORS. Hypochlorinators, or solution feeders, introduce chlorine into the water supply in the form of hypochlorite solution. They are usually positive displacement piston or diaphragm mechanical pumps. Selection of a feeder depends on local conditions, space requirements, water pressure conditions, and supervision available. Hypochlorinators are sometimes used as stand-by equipment for gas chlorinators. There are many makes of chemical feed equipment: (1) Proportioneers Chlor-O-Feeder is a positive displacement - diaphragm type pump, (2) Wallace and Tiernan Hypochlorinator is a positive-displacement diaphragm, and (3) Model S Hypochlorinator is a positive-displacement diaphragm pump.

Hypochlorinators are basically constructed on the same principles which employ a diaphragm, piston rod to move diaphragm, check or poppet valves, stroke adjuster, transparent plastic head, and an electric motor. See figures 2-20 and 2-21 for typical chlorinator. The operation of chlorinator or chemical feed is basically the same. The suction stroke of the diaphragm draws solution from the solution tank into the pumping chamber, through discharge tubing into the main water line. The pumping chamber has check or poppet valves on the inlet and outlet ports that open alternately with each pump stroke, thus keeping the solution moving in one direction only. (See figures 2-20 and 2-21.) The pumping chamber consists of a transparent plastic head that aids in visually inspecting the pump for operation. The diaphragm and poppet valves are molded from synthetic rubber.

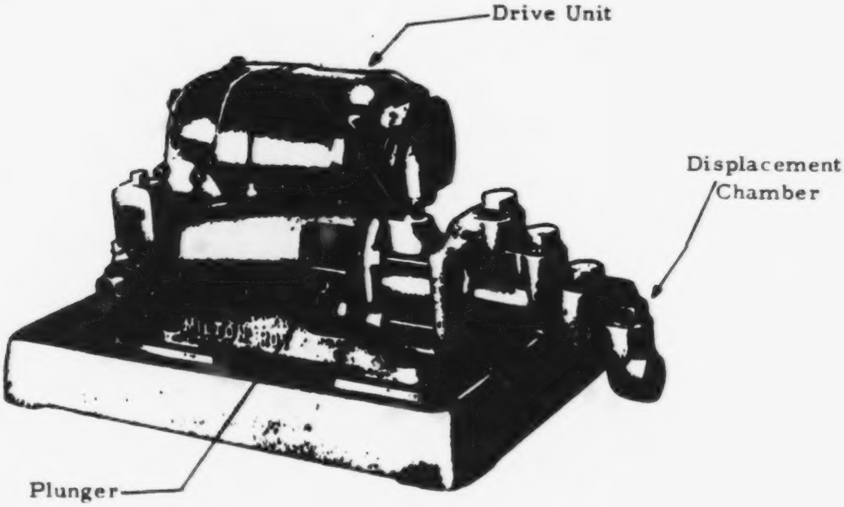


Figure 2-20. Chemical Feed Pump

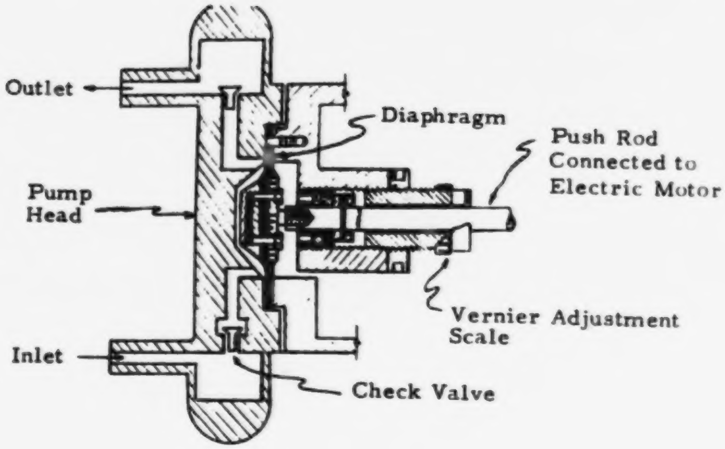


Figure 2-21. Cross Section of Typical Diaphragm Pump

Chlorination Controls

Correct chlorine dosage destroys all pathogenic organisms, except certain amoebae cysts which can be removed by filtration, and provides enough residual to protect the water in the distribution system. In its flow through the distribution system, the residual is reduced by aeration in storage tanks, reaction with plant and animal life and other organic material in the system, and with slowly oxidizing substances in the water. It is therefore frequently necessary to provide an initial residual higher than minimum requirements to maintain the minimum distribution system residual.

RESIDUAL TESTS. Chlorine residual tests are the basis of chlorine control. When the distribution system chlorine residual losses are relatively high, the residual required at the point of application is determined from local experience. However, this relationship changes with water temperature, quality, and rate of consumption, and with the amount of organic matter and slimes in the distribution system. Daily tests of residuals in the distribution system are therefore necessary. The amount of chlorine residual required for adequate disinfection is that which will insure the destruction of pathogenic organisms as demonstrated by bacteriological examinations.

Procedure for Performing the Chlorine Residual Test:

1. Obtain water sample.

2. Rinse the two test tubes with sample to be tested.

3. Add 0.5 ML ortho-tolidine (OTD) to one test tube.

4. Add 10 ML of sample to the other test tube.

5. Transfer the 10 ML sample to the other test tube.

IMPORTANT: The reason for transferring the 10 ML sample to the second test tube is to permit a good mixture between the OTD and the sample, thus preventing the possibility of contamination while handling.

6. Fill second test tube with 10 ML of sample.
7. Select the proper disc and place in comparator.
8. Place the two test tubes in the comparator making certain the sample with OTD is in the right hand side of the comparator.
9. Holding the comparator to a source of light rotate the disc until a color match is made.
10. Read the chlorine content in the window of the comparator.
11. Record the chlorine content and reserve for further use.
12. Clean and store equipment to its original position.

CHECKING RATE OF FEED. To ascertain that chlorinator is feeding the indicated amount, the cylinders are usually mounted on a platform scale. Loss in weight during the check period is observed.

$$\text{Rate of feed} = \frac{\text{Loss in weight} \times 24}{\text{Check Period in Hours}} = \text{Pounds per day.}$$

Rate of feed of hypochlorinators is found from the loss in volume of gallons of solution by determining change in depth of solution in its container. Knowing the solution strength, the pounds chlorine used can be calculated. Substituting this figure in the above equation, for the loss in weight, the pounds per day rate can be determined.

Chlorination Operation and Safety Precautions

CHLORINATION OPERATION PRECAUTIONS. Chlorine gas is extremely irritating to sensitive tissues of the eyes, mouth, throat, and nose. Repeated exposure to relatively low concentrations may have a cumulative effect on lung tissues. Because chlorine is heavier than air, exhaust fans are installed to draw air from the lowest point in the room. The exhaust systems blowers or fans, must have their switches readily accessible from the outside.

Chlorine is noncorrosive when dry but very corrosive when moist. Parts coming in contact with chlorine solution must be made of silver or other noble metals, tantalum, glass, rubber, or certain synthetic compounds.

Chlorine reacts with greases, oils, ethyl alcohol, and ether to produce solid compounds which clog fittings and chlorinator parts. Wood alcohol is the best cleaning agent to remove these compounds. Extreme care must be taken to provide adequate ventilation while using it.

If chlorine gas is drawn off too rapidly, frost forms on cylinder and lines. Freezing retards passage of the gas. Maximum safe rates from 150 pound cylinder is 40 to 50 pounds per day and 400 pounds per day from one-ton cylinders.

Each cylinder valve is equipped with a fusible plug of an alloy designed to melt between 157°F and 162°F for the purpose of releasing the contents of the cylinder in the event of fire or other exposure to high temperatures.

Use a paste of freshly mixed litharge and glycerin to make up threaded joints. Support piping securely, slope piping so it drains back to cylinder.

Open chlorine valves slowly and carefully, using a wrench of proper size (not longer than six inches). Open valves only part way; one full counterclockwise turn of the valve stem permits maximum discharge.

Close valves as soon as cylinder is empty and crayon mark the cylinder with a large "E".

When a chlorine odor is noted, authorized employees will start the ventilating system, put on their gas mask, and locate the leak by holding the mouth of an unstoppered bottle of ammonia water close to pipes, fittings, and valves. Ammonia vapor and chlorine gas form heavy white fumes, thus revealing the point from which chlorine is leaking. After leak is located, shut off flow of chlorine and repair leak. If cylinder head is leaking and cannot be stopped, waste the gas from the cylinder outdoors in a good wind or run it into a caustic soda solution. A solution of 25 pounds of caustic soda in ten gallons of water will absorb 20 pounds of chlorine gas.

CHLORINATION SAFETY PRECAUTIONS

1. Maintain only the supply of chlorine in any chlorinator room sufficient for normal daily demands.

2. Allow only reliable and trained men to handle chlorine.

3. Handle containers carefully to avoid dropping or bumping them.

4. Avoid hoisting containers as much as possible; if hoisting is necessary, use safe lifting clamps.

5. Store cylinders in a cool place, away from dampness, steam lines and fire, and in an upright position, secured from tilting and falling.

6. Keep protective valve caps on containers when not in use.

7. Never connect a full cylinder to a manifold with another cylinder unless temperature of both are approximately the same.

8. When chlorine is not being drawn or is empty, keep the valves closed.

9. Disconnect valves as soon as containers are empty and check for chlorine leaks at valve outlets.

10. When chlorine leaks occur, only qualified personnel, with suitable respiratory equipment, will be assigned to investigate and correct the trouble.

11. Do not apply water to chlorine leak as it is very hazardous and results in corrosive action which will enlarge leak.

12. Never apply flame or blow torch or other direct heat to chlorine containers.

13. Temperature of a chlorinator room should be about 70°F.

14. Never ship a defective or leaky cylinder unless it is completely empty. Paint "DEFECTIVE" plainly on all such cylinders.

15. Follow all regulations on shipping, storing, and using compressed gas cylinders.

16. Never use a chlorine cylinder for any purpose other than holding chlorine gas. Do not refill cylinders.

17. Provide proper means of egress from areas where chlorine is stored or used.

18. A gas mask is provided for handling chlorine. Mask should be located near, but outside of, chlorine feeder and storage areas. A minimum of two gas masks at each chlorine feeder or storage area.

19. Administer first aid to victims as soon as they are removed from the area of the leak. If the victim is unconscious and not breathing, use the mouth-to-mouth or back pressure arm lift method of producing artificial respiration. Summon qualified medical assistance immediately.

FLUORIDATION AND DEFLUORIDATION

In recent years statistical studies have been made showing that where naturally occurring fluorides were present in appreciable amounts, indicated tooth decay among the residents was surprisingly low, especially among children and young adults. This condition generally held throughout their life span. Subsequent large scale experimentation in certain cities of the United States indicated that where fluoride dosages were applied in controlled optimal amount of about 1.0 ppm to the water supply, cavities in children were reduced from 40 to 60 percent. Installation for the application of fluorine (either in the form of fluorides such as sodium fluoride, or of acids such as hydrofluosilicic acid) must have the approval of the Surgeon General, U.S. Air Force.

This information will be discussed under the following main topics:

- Fluoride Compounds
- Equipment
- Application
- Dosage
- Sampling
- Testing
- Defluoridation
- Safety Precautions

This study guide will not contain all the information you will need to know; therefore, the study of additional material is recommended. The additional study material is listed at the end of this study guide.

Fluoride Compounds

There are three fluoride compounds commonly used in fluoridation. They are sodium fluoride (NaF), sodium silicofluoride (Na_2SiF_6), and hydrofluosilicic acid (H_2SiF_6). The first two are dry, white, crystalline salts in powder form, and the last is a corrosive liquid. All are toxic chemicals and must be handled with extreme care, from the standpoint of both bodily contact and inhalation of dust if in powder form.

The powder chemicals are generally packaged in 100-pound paper bags or 350-400 pound fiber board drums; acids are usually obtained in 100-pound or 55-gallon rubber lined steel drums.

Store all chemicals in a dry room convenient to feed equipment. To protect chemicals from damage, place packages, including steel drums, on boards or grids to permit air circulation to prevent moisture forming on the container bottom. Hopper filling openings should be at a suitable height to avoid the use of ladders and platforms.

Equipment

Fluorides are proportion fed into water either as liquids or solids. Chemical feeders can be broadly divided into two types: solution feeders, which are essentially small pumps, used to feed a carefully measured quantity of accurately prepared fluoride solution (hydrofluosilicic acid) during a specific time, and dry feeders which deliver a predetermined quantity of the solid material during a given time. Dry feeders can be further divided by types depending on the method of controlling the rate of feed. Volumetric dry feeders deliver a predetermined volume of dry chemical within a given time; gravimetric feeders (loss in weight) deliver a predetermined measured weight of chemical within a given period.

Volumetric feeders (Figure 2-22) will deliver as little as three to four ounces per hour to treat supplies of 200,000 gallons or more daily. Gravimetric feeders (Figure 2-23) will feed as little as one pound per hour but are generally used to treat supplies of five million gallons or more daily.

Figure 2-22. Volumetric Feeders

Figure 2-23. Gravimetric Feeders

Volumetric Type Dry Feeder

The maximum rate of feed for the machine at any Air Force plant should not exceed 12 pounds per hour and the hopper should hold at least 100 pounds but not more than 200 pounds of chemical. The hopper should be equipped with an agitator to prevent arching and assure a continuous chemical feed at all times. The feeder must feed the chemical uniformly. Rate adjustment apparatus permits precise adjustment of the feeding rate. Feeding mechanism must be completely inclosed to prevent any escape of dust. It is advisable to provide as an integral part of the feeder a weighing device or a platform scale and a loss in weight indicator-recorder which will continuously indicate and record the weight of chemicals in the hopper. The solution chamber must be completely resistant to corrosion, and provide a removable cover and a dust tight flexible connection to the feeding mechanism. The volume of the solution chamber (dissolver) should be at least one gallon per pound of sodium fluoride fed per hour at maximum rate of feed. For sodium silicofluoride, the volume should be at least five gallons per pound fed per hour. Regardless of the chemical feed rate, the volume of the dissolver should exceed 10 gallons.

GRAVIMETRIC LOSS IN-WEIGHT TYPE DRY FEEDER. This feeder differs from the volumetric in that, instead of displacing a preset volume of chemical, a definite weight of the chemical is displaced. A higher degree of accuracy is obtained. The scales, hopper, all the mechanism, and the dissolver or solution chamber should be inclosed. A totalizer should show the total amount of chemical fed, in pounds, on a direct reading counter without the use of multipliers. The accuracy of the totalizer should be better than 99 percent. The hopper capacity and scale beam capacity should not exceed 250 pounds.

PROPORTIONING PUMPS. At installation where water is purchased and fluoridation is desired, arrangements can be made with the contractor to fluoridate water supplies. Where the source of water is from wells pumping to a central point a proportioning pump may be installed to inject fluoride. Where wells are not pumping to a central point a proportioning pump must be provided for each well. The most commonly used solution feeders are positive displacement diaphragm pumps with feeding heads constructed of polyvinyl or methyl methacrylate plastic and neoprene, which are resistant to fluoride chemicals.

For these installations the most accurate and economical method of fluoridation is by the application of sodium fluoride solutions of less than four percent. For the preparation of solutions less than saturated (four percent), a weighted amount of the chemical is added to a definite weight or volume of water and the mixture is mechanically or manually stirred until a homogeneous solution exists. Often two reagent tanks are used, one tank being prepared while the other is in use. Each tank should have sufficient volumetric capacity to hold a 30 hours' supply of reagent. For testing and measuring purposes the reagent tank should have a scale attached to the inside that can be read by the operator. A sight glass may be installed. Water used for making sodium fluoride solutions is zeolite softened or treated with sequestering agent such as calgon, nalco 918, or equivalent where the total hardness exceeds 100 ppm expressed as calcium carbonate.

Application

In feeding fluorides it is not necessary to allow for a contact period as with chlorination. Water has no "fluoride demand," hence the entire quantity can be accounted for in the distribution system unless it is lost through treatment processes. Ordinary filtration occasions a loss of 0.1 to 0.3 ppm of the fluoride added. The most desirable point of application is in the filter effluent or at the entrance to the clear well. At installations using well water, the solution is normally injected into the discharge from the well pumps unless water is discharged to a central point of storage. Fluoride chemicals are added after all other chemicals have had an opportunity to react, but prior to final chlorination.

Dosage

In fluoridation practice the target residual in the distribution system is prescribed for each installation by the Surgeon General. In general the spread is from 0.7 to 1.2 ppm fluoride in the finished water supply, the average being about 1.0 ppm. To determine the dosage that will give a residual of 1.0 ppm, the natural fluoride content of the raw water must be considered. Chemical dosage must be set and supervised by properly authorized personnel. Over-all dosage checks are made at least daily. Continuous observation of the equipment is a daily routine operation. Hourly checks reflect any dosage variations and provide a basis for regulation of overfeed or underfeed.

Sampling

Representative composite samples from the treatment plant effluent are collected and analyzed daily in addition to the dosage checks for plant controls. Sampling from representative points in the distribution system are performed at least weekly and preferably twice a week as a further means of evaluating the effectiveness of plant control.

Testing

Chemical analysis will be in accordance with methods in "Standard Methods for the Examination of Water, Sewage and Industrial Wastes." For plant control, analysis may be by colorimetic methods. If plant laboratory control is not available at an installation, samples may be shipped to a designated laboratory for analysis.

Defluoridation

Methods for the removal of excessive fluorides from water were made available soon after it was discovered that excessive fluorides contributed to fluorosis. Youths continuously exposed to water containing about 5 ppm or more fluoride are invariably afflicted with mottled enamel of the permanent teeth; many of these youths eventually lose their teeth through attrition.

At present, there are three methods of defluoridation which have proved practicable for the removal of excess fluorides. These methods involve the use of activated alumina, bone char, or magnesium compounds. The activated alumina and bone char employ an insoluble granular media which remove the fluorides as water filters through them. They are periodically regenerated as they become saturated with the fluorides. This is accomplished by chemical treatment. The use of magnesium compounds to remove fluorides are employed so that they are removed with magnesium which might be added in the form of lime. They are subsequently removed through the use of settling basins and then discarded.

Safety Precautions

Water plant operators who handle fluoride compounds must be trained to protect themselves from hazardous accidental exposures. Fluoride dust may cause irritation of the skin and mucous membrane.

All water plant operators should be fully orientated on the following safety rules:

1. Breathing of fluoride dust should be avoided. In case of spillage, clean up immediately.
2. Wear rubberized gloves, plastic or rubber aprons and masks when exposed to the dust.
3. Dust must be removed immediately from the skin by bathing or washing.
4. Rubber gloves, rubber boots, and acid proof aprons are required for handling of Hydrofluosilicic acid. After using equipment it should be washed thoroughly.
5. Personnel with open cuts or sores should NOT be allowed to handle fluoride dust or acids.
6. Detailed instructions on handling and safety precautions to be taken will be posted at the point of operation and adequately enforced.
7. All fluoride containers must be labeled with a sign warning that a poison is contained therein.
8. Containers are disposed of by incineration or burying in the sanitary fill.
9. When handling hydrofluosilicic acid, care should be exercised not to spill it on the body or clothing; should this happen, wash and flush immediately.
10. First Aid:
    a. Should internal poisoning occur the patient should immediately drink either a one percent solution of calcium chloride, a glass of lime water (saturated solution of calcium hydroxide), or a large amount of milk.
    b. For external injuries wash the area with a large amount of water.
    c. Should chemicals affect or enter eyes, flush immediately with warm water.
    d. In all events of injury and poisoning immediately seek medical aid.

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SUMMARY

Stabilization of water is necessary to prevent either scale buildup or corrosion in the distribution system. Stabilization can be accomplished through addition of polyphosphates or recarbonation.

Disinfection is the single most important treatment given to water. The most common disinfectant used by the Air Force is chlorine, either in gas form or liquid. Chlorine gas may be introduced by either direct feed or solution feed chlorinators. Chlorine solutons may be introduced through hypochlorinators. Because chlorine is hazardous to work with, you must follow prescribed safety procedures.

Fluroides in the range of .7-1.2 ppm in water has been found to be extremely beneficial in preventing tooth decay. However, too much fluoride causes permanent discoloration of tooth enamel called "mottled teeth." Therefore, close monitoring of fluoridation or defluoridation as needed is essential.

EXERCISE III-2-2d

INSTRUCTIONS

Complete the following questions. You can consult your instructor if you have any questions.

1. What is the purpose of stabilization? ______________________________

____

2. What are two common methods of stabilizing lime softened water?

____

____

3. Where in the water treatment process is stabilization treatment added to the water?

____

4. List by symbols and chemical name, five different types of chlorine which are available for disinfectant use.

____

____

____

____

____

5. Define the following:

a. Chlorine Residual ______________________________

____

b. Free available chlorine ______________________________

____

c. Combined available chlorine ______________________________

____

d. Chlorine dosage ______________________________

____

e. Chlorine demand ______________________________

____

f. Disinfecting time ______________________________

____

6. The effectiveness of chlorine ______________ with rise in temperature, but is retarded with a ______________ pH.

7. What are four types of disinfection?

____

____

____

____

8. Name two types of equipment used in chlorination.

____

____

9. List the chemicals names and formulas of three (3) compounds which are used for fluoridation in our water treatment.

____

____

____

10. How are excess fluorides removed from water? ______________________________

____

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

SW J3ABR56631 000-III-3

MONITOR/OPERATE AND MAINTAIN WATER TREATMENT PLANT EQUIPMENT

OBJECTIVES

Given statements about chemical mixing tanks, identify as true or false the statements concerning the monitoring and operation of chemical mixing tanks.

During a field trip to the local municipal water treatment plants, monitor the operation of plant components by making a written response IAW a checklist. No more than three instructor assists are allowed.

Using information and the water plant trainer, work as a team to monitor/operate the trainer with no more than three instructor assists.

Using information and the water plant trainer and equipment, work as a team to perform the required maintenance on the trainer and equipment. Four of the six maintenance problems must be performed correctly. No more than two maintenance problems may be missed.

Using AFR 91-26 complete statements concerning the purpose and types of aerators. Five of the seven must be correct.

Using AFR 91-26 match the maintenance procedures used for each type of aerator. Three of the five must be correct.

INTRODUCTION

Municipal water treatment plants vary in size and method of treatment according to the needs of the municipality. The Wichita Falls plants are examples of lime softening, horizontal clarification systems. An accelator is also seen at the old plant as an example of the cold lime-soda softener system.

As an Environmental Support Specialist you need a thorough understanding of the principles of operation of the plants and the equipment used.

INFORMATION

MONITOR PLANT COMPONENTS DURING FIELD TRIP

The Wichita Falls water plants that you will monitor are named for the streets that they are found on, such as the Cypress Street plant, which is a 16 MGD plant with a 50% overload and the Jasper Street plant which is a 12 MGD plant with a 25% overload. An upflow clarifier rated at 10 to 11 MGD will be seen at the Jasper Street Plant.

The Cypress and Jasper Street plants are lime softening, horizontal clarifiers. The water source is from two lakes, Arrowhead and Kickapoo. The water from these lakes is pumped to a secondary reservoir at the edge of town. This reservoir is 15 feet deep, covers 10 acres and holds 50 MG of water, it allows for plain sedimentation and a storage of raw water. Both of these plants have recovery wells, an open tank 50 feet in diameter and 45 feet deep, and lagoons are used to handle the backwash water from the filters.

You will be exposed to open tanks, chemicals, wet floors and other conditions common to a water treatment plant. For your protection observe the safety precautions you have learned from AFR 127-12.

PLAIN SEDIMENTATION

Plain sedimentation is the process of removing or reducing the amount of mud, clay, or silt entering the water plant without the use of chemicals. The solids will settle to the bottom if the flow of water is slow enough. This is done in the secondary reservoir.

Aeration also takes place in the secondary reservoir. The raw water is pumped into the air upon entering the reservoir. This allows dissolved gases to escape and oxidizes iron compounds.

Chemical Mixing and Storage

Chemical mixing tanks vary in size, type of construction and materials. They can be purchased or locally manufactured, have mechanical mixing, use the velocity of the water flow, or simply allow the chemical to dissolve in them. Mixing tanks are sometimes used as storage and mixing combined.

Horizontal Sedimentation Clarification/Softener

The main items in operation of settling basins are (1) control of quantity of water flowing through the basin, (2) removal of sludge from the basin, and (3) cleaning the basins.

(1) Controlling the quantity of water flowing through the settling basin is accomplished by the use of the plant metering devices or by periodic checking of the discharge rate of the raw water pumps. In cases where the raw water enters the plant by gravity flow, an orifice plate, venturi tube, or other type of meter, and a control valve should be installed so the flow can be controlled.

(2) Sludge removal from settling basins may be either intermittent or continuous. For settling basins not equipped for continuous sludge removal, it is necessary that an adequate number of drain valves are opened periodically and the sludge removed by gravity drainage. Continuous removal of sludge has been found to be more satisfactory and efficient, particularly where there is a considerable quantity of sludge to be removed. For round and square settling basins a spiral type rake is installed in the bottom of the tank; the rake rotates and moves the sludge to the center of the tank where the sludge drain is located. The bottom of the tanks is usually sloped toward the center to aid in moving the sludge toward the drain. For rectangular basins, scrapers are provided so they will drag sludge along the floor of the basin, carrying the sludge to the sludge hopper at one end of the tank. Some of the sludge may be returned to the influent line. By doing this, it will aid in coagulation and increase the settling rate.

(3) Generally, sedimentation basins are cleaned at three-month intervals or when an odor indicates that septic sludge conditions are developing. The area or climate will also determine when the basin will be cleaned.

Filters

Water from the sedimentation basins is brought into the filters as the next step in the purification process. This water contains very finely divided suspended matter such as minute particles of floc, clay, and mud that have not combined into one body, and bacteria and microscopic organisms that have not been removed by sedimentation. The purpose of the filter is to remove this suspended matter and give the water a clear, sparkling, and attractive appearance.

Chemical Feeders

Continuous softening requires application of chemicals in proportion to the rate of flow of water through the treating units. If the flow is constant over a definite period of time, the chemicals can be fed through constant-feed machines. If the flow is variable, proportioning devices are used to feed chemicals in suspension or solution.

Soda ash dissolves easily in water to form a clear stable solution. After preparation, the solution needs no further agitation and can be added directly to the water through a proportioning device.

Lime, being only slightly soluble in water, forms a suspension known as milk of lime. Because suspended matter tends to settle, continuous agitation is necessary to keep the mixture uniform. Therefore, devices for feeding lime usually have mechanical agitators. Flow through feedlines must be fast enought to keep the lime from settling and clogging the lines. Long lines should be avoided or should be easily replaceable. They should have pressure connections for flushing. Rubber hose or open troughs are frequently used in place of pipes.

Some plants feed lime and soda ash through one proportioning device. Chemicals are mixed with a water in the proper proportions, and introduced as a thin slurry. This method is satisfactory where the composition of raw water is constant or does not change rapidly.

The chemical feeders used may be either of the wet or dry type, the latter type generally being employed only with the larger sizes of units. In the wet type feeder, the hydrated or slaked lime is fed largely in the form of a suspension, usually of about a 5 percent concentration. Where soda ash is also used with the wet type feeder, it is usually dissolved in and fed with the lime suspension instead of being fed separately. The coagulant is dissolved in and fed from a separate chemical feeder. When dry feeders are used, separate feeders are used for the lime, the soda ash, and the coagulant.

Measuring Devices

The main device used to measure the flow through the water treatment plant is the Parshall Flume, which also acts as a mixer.

Control Devices

The control devices used at the water treatment plant are numerous and located throughout the plant.

Valves

The valves used at these plants are gate or globe and are operated hydraulically or pneumatically.

Upflow Clarifier

This cold lime-soda water softener is in use at some missile sites and at some Air Force bases. Since it has the capacity of softening large quantities of hard water containing calcium and magnesium salts, this section will cover the common types of cold lime-soda softeners, operation of the accelator, and the theory of operation.

There are four basic types of cold lime-soda softeners, namely: (1) the sludge blanket type, (2) continuous sedimentation type, (3) the "catalyst type," and (4) the intermittent or batch-process type. The first three are continuous types; that is, the water is treated as it is flowing through the equipment. The fourth type is, as its name indicates, one in which the flow of water is not continuous but intermittent, as the water is treated in separate batches. Of these, the sludge-blanket type, owing to its "higher efficiency, short detention period, and smaller space requirements, is rapidly replacing the conventional type for industrial use. It is also widely used in the municipal field, but some state boards of health prefer longer detention periods than the customary one-hour detention period in the sludge-blanket type. This continuous sedimentation type is an older type. The catalyst produces a granular type of sludge which can be handled readily and which drains and dries rapidly.

This type differs from the sedimentation type in that the treated water is filtered upward through a suspended sludge blanket composed of previously formed precipitates. There are several distinct advantages gained by this procedure. First, the upward filtration through the suspended sludge blanket results in the complete solution and use of the added lime. Second, the close contact of the treated water with a large mass of the sludge blanket prevents saturation. Third, the upward filtration in the sludge blanket results in the production of water which is clear enough without filtration for many industrial applications. Fourth, the detention period is much less for this type.

In size, the vertical softeners may range from capacities of a few thousand to 10,000,000 gallons per day. Note that the outer chamber has a smaller conical section with its base more narrow than the top side. The raw water and the treating chemicals are introduced into the top of the inner chamber where they are thoroughly mixed by means of a centrally located mechanical agitator which is motor driven.

FIELD TRIP TO MUNICIPAL WATER PLANT

INFORMATION

This criterion objective is a performance requirement. During the field trip to the water plants you must complete a progress checklist by answering several questions pertaining to the operational aspects of the plant and its support equipment. The checklist or questions will be furnished to you by the instructor. They will be accomplished during the field trip and turned in to the instructor prior to dismissal.

Pay particular attention to the instructor's lecture as you tour the plant to complete your questionnaire.

INFORMATION

WATER TREATMENT PLANT TRAINER

The water treatment plant trainer with the cascade aerator, chemical mixing tank, horizontal sedimentation clarifier/softener, and filter was designed for the purpose of training here at Sheppard. It accomplishes everything that the water plants in Wichita Falls does.

The operation procedures are in your WB J3ABR56631 000-III-3. These instructions will aid you during the operation of the unit. If you have any problems, the instructor will give you further instruction.

EXERCISE III-3-3a

WATER PLANT TRAINER (SOP)

INSTRUCTIONS

Follow the procedures listed below for operating the water treatment plant.

PREOPERATION

1. Close all drain valves.
2. Turn off all electrical switches.
3. Check oil in chemical feeder.
4. Mix chemical solution in chemical supply tanks.
5. Adjust chemical feeders to desired feed rate.
6. Connect the master switch panel and the settling chamber motor to a 110-volt outlet.
7. Connect the chemical feeder, rapid mixer, and flocculator to the master switch panel outlets as marked.

OPERATION SEQUENCE

1. Open the globe valve on the inlet water supply and control the water flow rate at one and half (1-1/2) gallons per minute.
2. When the chemical mixer is half (1/2) full, turn on the following switches:
   a. Master
   b. Chemical feeders (right and left)
   c. Rapid mixer
3. When the flocculator is half (1/2) full, turn on the motor switch.

4. When the settling chamber is full continue with the following:
   a. Open the filter inlet valve two (2) turns.
   b. Turn on the settling chamber effluent pump switch.
   c. Open the filter effluent valve one turn.
   d. Turn on the hypochlorinator.
5. When the filter is full, turn on the clear well pump switch and open the clear well effluent valves.

BACK WASHING THE FILTER

1. Turn off the settling chamber and clear well pumps.
2. Close the filter influent and effluent valves.
3. Open the filter drain valve.
4. Turn off the hypochlorinator.
5. Open the water lower effluent valve.

SHUTDOWN EXERCISE

1. Turn off all electrical switches.
2. Disconnect electrical power.
3. Close the globe valve on the inlet water supply.
4. Open all drain valves.
5. Close all influent and effluent valves.

EXERCISE III-3-3b

INSTRUCTIONS

Complete the following questions. You may consult the instructor if you have any questions.

1. What chemicals were used in the trainer? ______________________________

   ____

2. What is the purpose of each of the chemicals used? ____________________

   ____

3. What type of clarification system does the trainer represent? __________

   ____

4. What type of filter is used? ____________________________________

   ____

5. What type of scraper is used in the sedimentation tank? _______________

   ____

6. Is primary or secondary sedimentation or both used? How do you know?

7. Where is chlorination done?

8. What type of storage tank is used?

9. If the floc in the flocculator is settling, what would be the most likely cause?

10. If the floc starts to build up or accumulate in the sedimentation basin, what action should be taken?

11. If the backwash rate exceeds 15 gpm, what problem could occur?

12. What action is taken to control the chlorine feed?

INFORMATION

PROCEDURES FOR MAINTAINING WATER TREATMENT PLANT EQUIPMENT

Chemical Mixing Tanks

The chemical mixing tank must be drained and hosed out at the end of the operation of the unit. Flush out sediment, mud, scale, etc. Examine walls and make any necessary repairs.

Flocculator

During operation, check paddle rotaton by visual inspection or surface disturbances. At the end of operation, drain basin and thoroughly rinse out sediment. Inspect paddles and other mechanical parts for deterioration. Make repairs where necessary. Refer to AFR 91-26, Par 6-34e.

Horizontal Sedimentation Clarifier/Softener

This unit has a drive chain which must be checked for the following: proper adjustment, loose planks, excessive wear, and corrosion. Inspect the general condition of the baffle, for leaks at the corners and at the overflow trough. Perform maintenance as required. Refer to AFR 91-26, Par 6-34f, for further information.

Filters

The filter must be backwashed every 50 hours if there is no surface wash. During backwash you should probe the filter to check for hard spots. The underdrain should be inspected for cracks or loose joints. The filter must also be checked for mud balls, and encrustation of the top layer of sand. You may have to replace the first inch or two of sand. Inspect all valves for proper operation, repack or replace as needed. Refer to AFR 91-26, Par 6-44b and 6-45a

Wet Wells

Protect openings into clear well so that ground water cannot enter. Check all metal structural members and surfaces for corrosion due to chlorine vapors and replace where necessary. Before draining make sure all recording equipment is protected from damage while cleaning.

Water Towers

Inspect vent screens and manhole covers for tight fit. Unclog vent screens from snow and ice as necessary in winter months. Inspect for corrosion and leaks and repair as necessary.

EXERCISE III-3-3c

INSTRUCTIONS

Using AFR 91-26, answer the following questions.

1. What are two ways that you can check if the flocculator paddles are rotating?

____

____

2. What can cause the flocculator paddles to be inoperative? __________________

____

3. Why should underwater line shaft bearings be inspected carefully each time a basin is drained? ____

____

4. How is the speed of a flocculator controlled? __________________________

____

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AERATORS

INFORMATION

Purpose of aerators

Aeration consists essentially of exposing as much water surface as possible to the air. During aeration, gases dissolved in the water supply are released to the atmosphere; soluble iron salts are oxidized and become insoluble so they can be removed by settling. Aeration raises the pH by eliminating dissolved carbon dioxide but increases corrosiveness by increasing the amount of dissolved oxygen.

Types of aerators

The four different types of aerators are the spray nozzle, cascade or step aerators, diffusers and tray and splash pan.

Spray Nozzle Aerator. A pipe or group of pipe openings spraying water up or down over a shallow receiving basin exposing a large surface area of water to the air.

Cascade or Step Aerators. Allowing water to fall over a series of steps making it look like a waterfall.

Diffuser Aerator. Forcing air into a basin, like the air line in a fish tank.

Tray and Splash Pan. This consists of overflowing trays containing salts or coke over which the water is sprayed (see figure 3-1).

The operation of most aerators is practically automatic. If the water is not to be filtered after aeration, aerators must be screened with a fine screen to keep insects and other foreign matter out.

The operators' duties consist essentially of making sure pipes, slots and surfaces are not clogged and that air has free excess to the water.

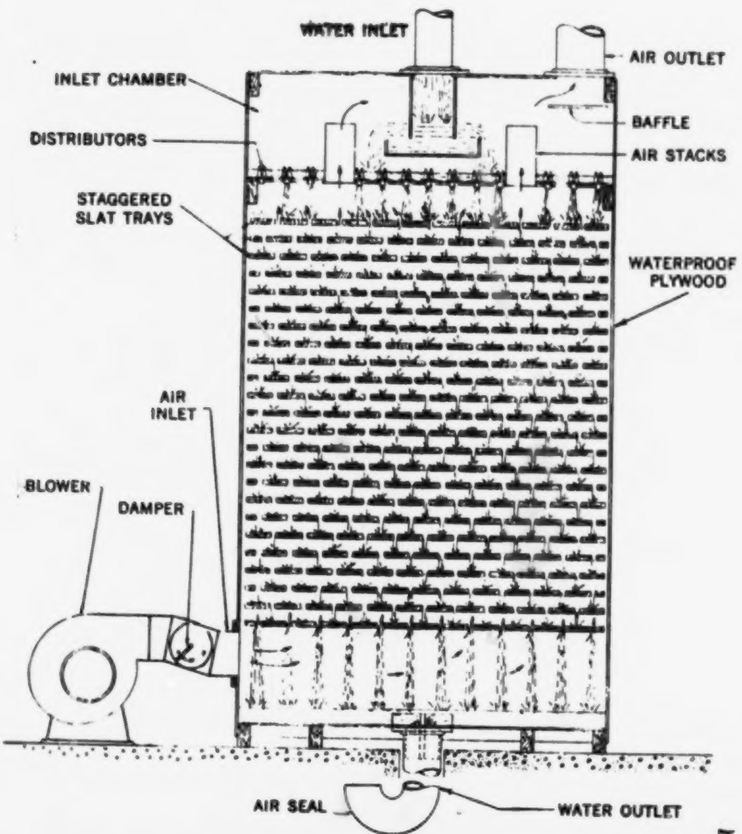
WATER INLET
AIR OUTLET
INLET CHAMBER
BAFFLE
DISTRIBUTORS
AIR STACKS
STAGGERED SLAT TRAYS
WATERPROOF PLYWOOD
AIR INLET
BLOWER
DAMPER
AIR SEAL
WATER OUTLET

Figure 3-1 - Forced Draft Aerator

EXERCISE III-3-3d

INSTRUCTIONS

Complete the following questions. You may consult the instructor if you have any questions.

1. What is the purpose of aeration? ____________________

2. How does aeration remove color caused by iron? ____________________

3. How does aeration change pH? ____________________

4. What chemicals are used to clean aerators? ____________________

5. What component should be checked with a diffused aerator if proper aeration is not taking place? ____________________

6. How does aeration remove taste and odor? ____________________

7. Name the four (4) types of aerators.

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INFORMATION

TYPES AND MAINTENANCE OF AERATORS

Spray Nozzle

On the spray nozzle type aerator, you should check the following things:

INSPECT AND CLEAN SPRAY NOZZLES. You should look at each nozzle to see if it is working properly. You must clean the nozzle if any debris is there.

CLEAN AND INSPECT PIPE MANIFOLDS. Take the caps off of the manifolds and clean out any sediment. You should check the pipe for leaks and repair when it is needed.

Cascade or Step

On this type of aerator, you should check the following things:

INSPECT FOR ALGAE. Check the aerator surface for algae, objectionable growths, and stains. If you must clean any part, scrub it and treat with copper sulfate and a solution of chlorine water.

REPAIR. You make any necessary repairs and replacements to the aerator surfaces.

Diffuser

On this type of aerator, you should check the following items:

CLOGGING OF DIFFUSER. Look to see if the diffuser is clogged. It will be clogged on either the air or liquid side. One cause is a suspended solids buildup inside the diffuser. The other cause is soot, pipe rust and other impurities of the underside of diffuser plates or inside diffuser tubes.

INSPECT AND CLEAN AIR DIFFUSERS. The air diffusers should be drained and inspected for joint leaks, broken diffusers, and other deterioration.

Tray and Splash Pan

On this type of aerator, you should check the following items:

INSPECT FOR ALGAE. See instructions under Cascade or Step Aerators.

REPAIR. Make any necessary repairs and replacements to the aerator surfaces.

INSPECT COKE. Examine coke for algae and deterioration. Replace coke if cleaning is not effective.

REPAIR SCREENS AND ENCLOSURES. Make necessary repairs.

SUMMARY

In the field trip the water plants and in operating the water treatment trainer, you see the functions of chemical mixing tanks, flocculators, sedimentation basins, clear wells, filters and other components.

Aeration serves to remove color and dissolved gases from the water supply. It also increases pH of the water and its corrosive qualities.

EXERCISE III-3-3e

INSTRUCTIONS

Complete the following questions. You may consult the AFR 91-26, Part II, Section 15 for information.

1. What tool may NOT be used on spray nozzle tips? ______________________________

   ____

2. What material is a spray fence usually made of? ______________________________

   ____

3. What chemicals may be used to treat algae? ______________________________

   ____

4. What is the best sign of a clogged diffuser? ______________________________

   ____

5. What is the minimum rate of air discharge through a diffuser? ______________

   ____

6. The concentrated ________________ used to clean the water sides of diffusers are very dangerous and must be handled with care.

3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

J3ABR56631 000-III-4

MONITOR/OPERATE AND MAINTAIN ION EXCHANGE (demineralization) UNIT

OBJECTIVES

Given terms and statements pertaining to an ion exchange unit, match the terms to the statements. Twelve of the seventeen must be correct.

Given information, ion exchange softener and demineralizer units, work as a team to monitor/operate the ion exchange unit, with no more than four instructor assists.

Given information and an ion exchange trainer, work as a team to maintain the unit, with no more than one instructor assist.

ION EXCHANGERS

INTRODUCTION

The water that we find in streams, lakes and wells is usually very hard. Hard water will cause scale to form in water lines and a hard crust to form in boilers. Hard water will also kill the effect of soap suds in laundries and homes.

About 100 years ago, a farmer in England discovered that hard water became soft when it trickled through some of his soil. Later it was found that certain types of sand called green-sand had the ability to make hard water soft. Much use was made of green sand until about 1930 when a synthetic material was invented. This new material was several times better than green sand. It could also be recharged by washing it with salty water. This new material was called resin because it was brown in color and resembled natural tree resin.

Information in this study guide/workbook will be covered in the following main topics:

- Theory of Ion Exchange
- Cation Exchange Process
- Anion Exchange Materials and Processes
- Exchangers Used in Combination
- Operation of Demineralizers

INFORMATION

Purpose

An ion exchange unit is used to take the unwanted ions out of the water and replace them with ions that are wanted. We use this process in both water softning and demineralization. Soft water is desirable because less soap is necessary for cleaning. Demineralized water (water which is free of minerals) is used for jet aircraft and in our lab.

Theory of Ion Exchange

Ion exchange is a reversible chemical reaction between ions in water and ions attached to solid materials.

An _ion_ is an atom or group of atoms that have gained or lost electrons. A cation is an ion with a positive charge and is formed by losing electrons. An anion is an ion with a negative charge and is formed by gaining electrons. Figure 4-1 lists common anions and cations.

CATIONS		ANIONS	
Calcium	Ca^{++}	Bicarbonate	HCO_3^-
Magnesium	Mg^{++}	Carbonate	$CO_3^=$
Sodium	Na^+	Chloride	Cl^-
Manganese	Mn^{++}	Nitrate	NO_3^-
Iron	Fe^{++}	Sulfate	$SO_4^=$
Iron	Fe^{+++}	Silicate	$SiO_3^=$
Aluminum	Al^{+++}	Phosphate	$PO_4^=$
Hydrogen	H^+	Hydroxide	OH^-

Figure 4-1. Most Common Cations and Anions Removed from Water by Ion Exchangers

Characteristics of Ion Exchange Resins

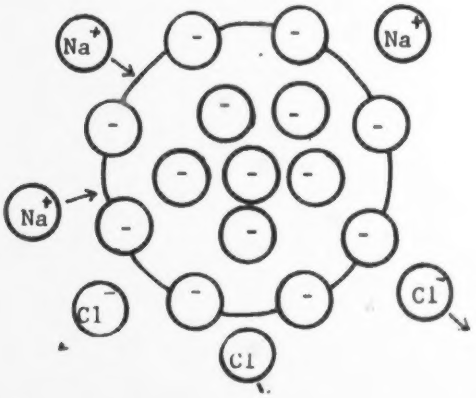
Ion exchange materials will not dissolve in water. They are able to release and to accept other ions in their place. The cation materials exchange positive ions for positive ions. The anion materials exchange negative ions for negative ions. The first softeners used natural sands called "zeolites." The term "zeolite" comes from two Greek words, Zein + Lithos, meaning boiling stones. In this course, the term ZEOLITE will refer to any ion exchange material.

There are four types of cation exchange materials used for water conditioning:

1. Natural sands (greensand, etc.)
2. Synthetic sands (silica-aluminum compounds)
3. Sulfonated coal
4. Cation exchange resins (sulfonated Polystyrene)
   a. Sodium cycle - NaCl (salt regenerant)
   b. Hydrogen cycle - regenerated with acid - HCl or H_2SO_4

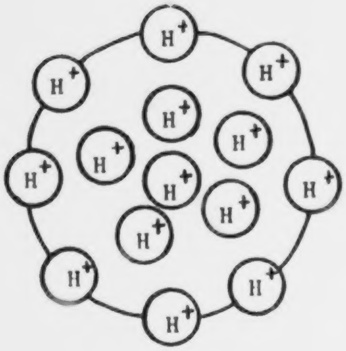
Of these materials, the plastic resins are more efficient and have higher exchange capacity so they are most widely used today.

Cation exchange resins are manufactured in such a way as to have hundreds of negatively charged cation exchange sites. These negatively charged sites will attract positively charged ions (cations) and repel negatively charged ions (anions).

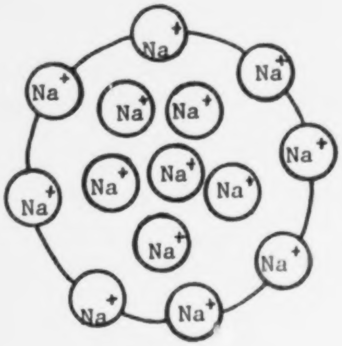


Cation Resin

Cation resins are put into use with the cation exchange sites covered with either sodium (sodium zeolite) or hydrogen (hydrogen zeolite).

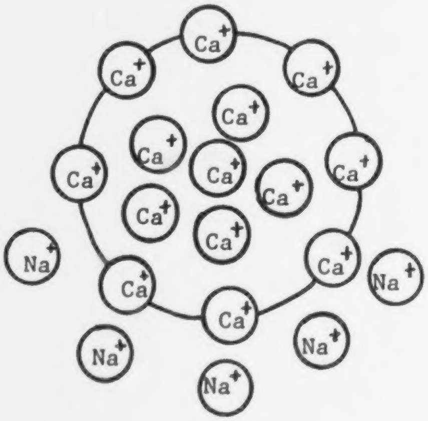


Sodium zeolite resin



Hydrogen zeolite resin

In the ion exchange process, hard water washes over the zeolite beads. The calcium or magnesium ions are exchanged for the sodium or hydrogen ions on the exchange sites. One calcium or magnesium ion takes 2 exchange sites because of the +2 charge. The sodium or hydrogen ion is released into the product water.



The process of ion exchange is reversible.

When all the exchange sites are covered with calcium or magnesium ions, the resin is said to be exhausted and must be "regenerated" by flushing them with a solution of NaCl for sodium zeolite or acid for hydrogen zeolite. This regeneraion works through the process of "mass action." The Na$^+$ or H$^+$ attaches itself to the negatively charged exchange sites where the calcium and magnesium ions had been trapped. That water is then washed out to waste and the resin is ready to work again.

Anion exchange resins work similarly but have positively charged exchange sites which attract anions and repel cations. Their exchange sites are usually covered with hydroxide ions which can be exchanged for sulfates, chlorides, and carbonates in the water.

Exchange Process	Material Used	Appearance	Normal Capacity Grains Per Cubic Foot	Regenerant Pounds Per Cubic Foot	Strength of Regenerant	Regenerant Chemicals	Test For Exhaustion	Characteristic of Product
Sodium Cation Na - Z	Green-sand (glauconite)	Grey-Green Granules	2,400 to 3,000 gr/cu ft	1.0 to 1.5 lbs/cu ft	3% to 18% Preferred 15%	Sodium Chloride Salt NA CL	1. Standard Soap 2. E.D.T.A Total Hardness	Soft Water No Calcium Magnesium Iron
	Sulfonated Coal	Black Granules	No Data	No Data				
	Sulfonated Polystyrene	Gold-Brown Spherical Beads	24,000 to 32,000 gr cu ft	6 to 15 lbs cu ft				
	Na Al SiO_2 Gel	White Granules	12,000 to 15,000 gr cu ft	4 lb to 6 lb cu ft				
Hydrogen Cation H - Z	Sulfonated Coal	Black Granules	6,000 to 8,000 gr cu ft	2 lbs to 4 lbs cu ft	H_2SO_4 2% - 4% First Step Last Step 6% - 8% HC1 6% - 10%	Sulphuric Acid Hydrochloric (Muriatic) Acid	1. pH 2. F.M. Acid	Contains Acid
	Sulfonated Polystyrene	Gold-Brown Spherical Beads	12,000 to 24,000 gr cu ft	4 lbs to 12 lbs cu ft				

Figure 4-2. Cation Exchange Materials and Processes

CLASS OF ION	MATERIAL USED	APPEARANCE	NORMAL CAPACITY GRAINS PER CUBIC FOOT	REGENERANT POUNDS PER CUBIC FOOT	STRENGTH OF REGENERANT	REGENERANT CHEMICALS	TEST FOR EXHAUSTION
WEAKLY BASIC ANION	POLYAMINE POLYSTYRENE	AMBER GRANULES	12,000 to 20,000 gr/cu ft	2 to 4 lb/cu ft	NO DATA	CAUSTIC SODA NaOH AMONIUM HYDROXIDE NH_4 OH $NaCO_3$	1. CONDUCTIVITY
STRONGLY BASIC ANION R + OH–	QUATERNARY AMINE POLYSTYRENE	YELLOWISH SPHERICAL BEADS	12,000 to 15,000 gr/cu ft	4.2 to 7 lb/cu ft	2% to 8%	CAUSTIC SODA NaOH ONLY	1. CONDUCTIVITY
STRONGLY BASIC ANION R + Cl–			5,000 to 16,000 gr/cu ft	4.0 lb NaCl Per cu ft	4% NaCl	SODIUM CHLORIDE NaCl (10% NaOH)	1. ALKALINITY

Figure 4-3. Anion Exchange Materials and Processes

Types of Ion Exchanges

CATION EXCHANGER. As mentioned before, there are two cation exchange processes in common use: sodium zeolite and hydrogen zeolite.

Sodium Zeolite. When hard water is passed through a bed of active sodium zeolite, the calcium and magnesium ions are taken up by the zeolite and at the same time zeolite gives up sodium ions; this reaction is shown below. (Sodium zeolite is represented by Na_2Z.) Iron and manganese are also removed if they are not over about 10 p.p.m. in the water.

SODIUM ZEOLITE PROCESS.

Example No. 1

$CaSO_4$ (solution)	+	Na_2Z (solid)	——>	Na_2SO_4 (solution)	+	CaZ (solid)
RAW WATER	+	SODIUM EXCHANGE RESIN		SOFT WATER	+	EXHAUSTED EXCHANGE RESIN

Example No. 2

$MgSO_4$ (solution)	+	Na_2Z (solid)	——>	Na_2SO_4 (solution)	+	MgZ (solid)
RAW WATER	+	SODIUM ZEOLITE		SOFT WATER	+	MAGNESIUM ZEOLITE

Example No. 3

WATER FLOW -- (HCO$_3$) H_2O + Ca)(SO$_4$ Mg) Cl) RAW WATER	+	Na Na Na Z Na	Produces >	Ca Mg Mg Z Ca	+	WATER FLOW H_2O + Na(HCO$_3$ (SO$_4$ (Cl
		A BEAD OF ZEOLITE		EXHAUSTED ZEOLITE BEAD		SOFTENED WATER

SODIUM ZEOLITE REGENERATION.

Example No. 1

2NaCl (solution)	+	CaZ MgZ (solid)	——>	$CaCl_2$ $MgCl_2$ (solution)	+	Na_2Z (solid)
BRINE		EXHAUSTED ZEOLITE		WASTE WATER		SODIUM ZEOLITE

Example No. 2

WATER FLOW CONTAINING 15% NaCl SALT	+	Ca Mg Mg Z Ca	Produces >	Na Na Na Z Na	+	WATER FLOW H_2O + NaCl + (Ca and Mg) Cl
BRINE SOLUTION SOLUTION		EXHAUSTED ZEOLITE		REGENERATED SODIUM ZEOLITE		WASTE SALT WATER

Calcium and magnesium chloride are soluble salts and are rinsed from the zeolite bed with clean water. Following regeneration, the exchange material is ready for another run to soften water.

Hydrogen Zeolite Process. Certain types of ion exchange beds can be regenerated with acid instead of salt. When this is done, hydrogen is made available rather than sodium during the softening process. The hydrogen is exchanged for calcium, magnesium, iron, and sodium ions, and the salts are converted into their corresponding acids. The reactions involved in the hydrogen exchange cycle are shown in the following equations.

HYDROGEN ZEOLITE EXCHANGE.

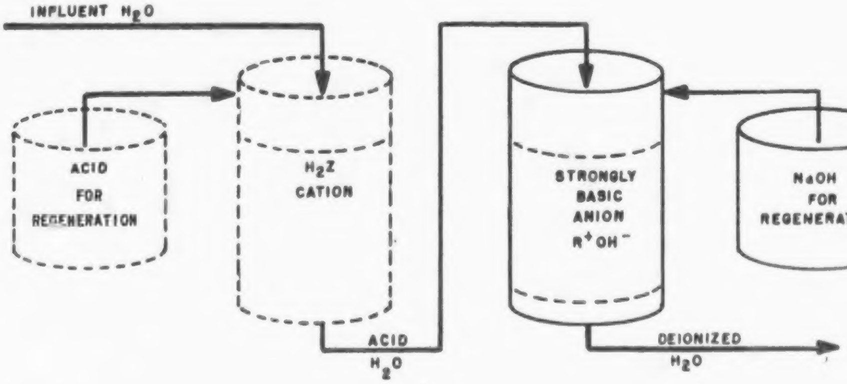
$CaHCO_3$ $MgCl$ $NaSO_4$ $FeSO_4$	+	$H_2Z \longrightarrow$	HCO_3 HCl H_2SO_4 H_2SO_4	+	Ca Mg Na Fe	Z
HARD RAW WATER		HYDROGEN ZEOLITE	TREATED WATER		EXHAUSTED RESIN	

Since the acids produced by the hydrogen ion exchanger are corrosive, the product water must be neutralized by a basic solution or anion exchange.

If sulphuric acid is injected into the resin stronger than 2% - 4% during the first few minutes of regeneration, the resin will be fouled with calcium sulfate ($CaSO_4$).

ANION EXCHANGER. There are two main types of anion exchange materials in common use in the Air Force: weakly basic resin, made of polyamine polystyrene; and strongly basic resin, made of quaternary amine polystyrene. See figure 4-3 for data on these materials.

Strongly Basic Anion, Hydroxyl Cycle. When the strongly base anion resins are regenerated with sodium hydroxide (NaOH), they are converted to the hydroxyl form (ROH). In this form they are used as the second stage of a demineralizer. The strong base material is the only one that will remove silica and it must be regenerated with NaOH to do it. (See figure 4-4 for this process.) The strong base process removes all acids from hydrogen zeolite water.



Service HCl (Acid H_2O) + $R^+OH^- \longrightarrow R^+Cl^- + H_2O$ Mineral Free Product

Regeneration R^+Cl^- + NaOH $\longrightarrow$ R^+OH + (NaCl + NaOH) R^+ = Resin
Exhausted Bed — Waste Water

Figure 4-4. Strongly Basic Anion, Hydroxyl Process

WEAKLY BASIC ANION PROCESS. The weakly basic anion exchange material (polyamine polystyrene) may be regenerated or "recharged" with soda ash, ammonium hydroxide or sodium hydroxide. This material is usually classed as the second stage of a demineralizer process where CO_2 and SiO_2 removal are not essential. This process removes only the strong acids - HCl, H_2SO_4, H_3PO_4.

Exchangers Used in Combination. The dual bed demineralizer consists of two separate tanks; Hydrogen cation material is contained in one tank, and an anion material is contained in the other. Cations such as calcium and magnesium are removed in the cation exchanger. Anions such as sulfates, chlorides, and nitrates are removed in the anion exchanger.

The cations are removed first by passing the raw water through the hydrogen cation exchanger. The effluent contains acid in proportion to the salts that were originally present in the raw water. The acids are then removed by passing the effluent through an anion exchanger. See figure 4-4.

The mixed bed demineralizer has both cation resins and anion resins mixed in one tank. This unit produces water of a very high degree of purity, resulting in less mineral salts than triple distilled water. The mixed bed demineralizer is a combination of hydrogen cation and strong base anion.

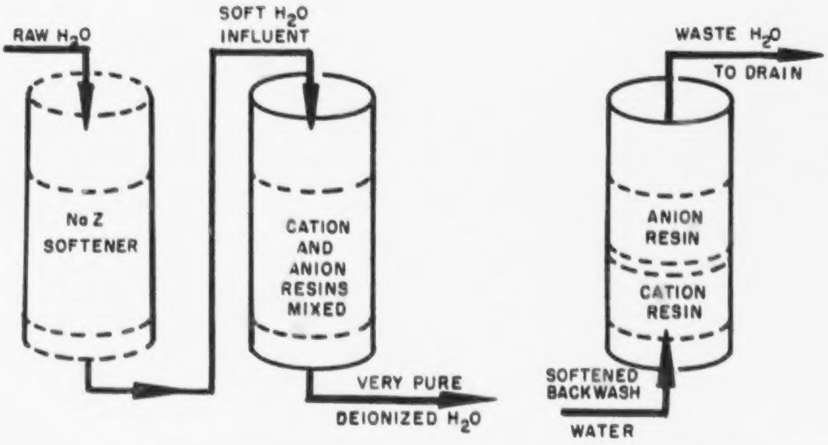
The mixed bed demineralizer operates on the same theory and principle as the dual-bed. Their cycles of operation are service, exhaustion and regeneration. The main difference between the two is the mixed unit utilizes only one ion exchange cylinder whereas the dual-bed utilizes two.

In regenerating the mixed bed units, the cation and anion resin beds are separated through proper backwashing. The anion exchanger bed, being lighter, comes to the top and the cation exchanger bed remains at the bottom. After separation, the two beds are regenerated individually with NaOH and acid. The excess regenerant is then rinsed from each bed and the two beds are mixed again by means of compressed air. A final rinse is then applied before the unit is put into operation. Refer to figure 4-5.

If raw water containing magnesium is allowed to enter an anion exchanger, the hydroxyl ion will join with magnesium and form the compound magnesium hydroxide $Mg(OH)_2$. Magnesium hydroxide is in water and will form scale on the resin by the following reaction:

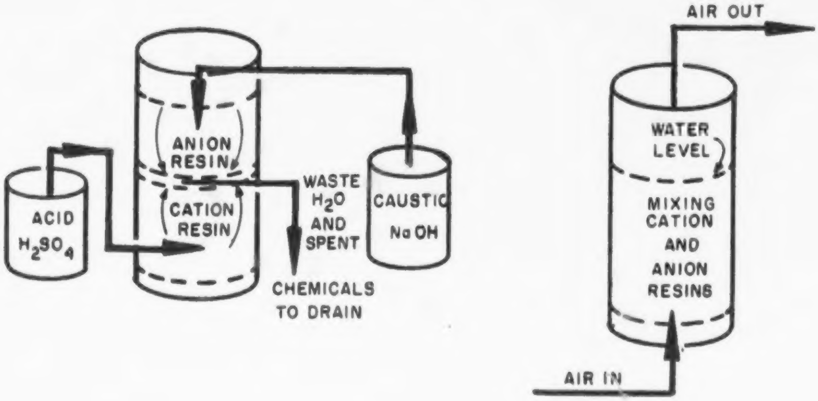
$$MgCl_2 \; + \; 2R^+ \; OH^- \longrightarrow Mg(OH)_2 \; + \; 2R^+Cl$$

Refer to figures 4-3, 4-4, 4-4 and 4-5, and note that all anion exchangers have a cation exchanger ahead of them in the stream. The HZ or NaZ will remove the magnesium or other cations that may cause trouble in the anion unit.


RAW H_2O
Na Z
SOFTENER
SOFT H_2O
INFLUENT
CATION
AND
ANION
RESINS
MIXED
VERY PURE
DEIONIZED H_2O
WASTE H_2O
TO DRAIN
ANION
RESIN
CATION
RESIN
SOFTENED
BACKWASH
WATER

A. SERVICE

B. BACKWASH STEP


ANION
RESIN
CATION
RESIN
ACID
H_2SO_4
WASTE
H_2O
AND
SPENT
CHEMICALS
TO DRAIN
CAUSTIC
Na OH
AIR OUT
WATER
LEVEL
MIXING
CATION
AND
ANION
RESINS
AIR IN

C. REGENERATION STEP

D. AIR MIX STEP

E. FINAL RINSE STEP SAME AS STEP "A" EXCEPT THE POOR QUALITY PRODUCT GOES TO THE DRAIN

Figure 4-5. Mixed-Bed Demineralizer

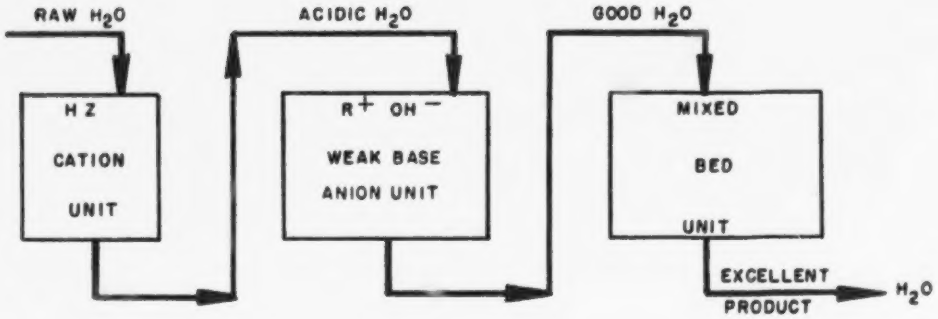


Figure 4-6. Combination Demineralizers

Components of Demineralizers

The major components of the unit are:

- (1) Exchange tank
- (2) Resin bed
- (3) Support Bed
- (4) Underdrain
  - (a) Collects product water
  - (b) Evenly distributes backwash water
- (5) Influent distributor
  - (a) Distributes influent water evenly
  - (b) Collects backwash water
- (6) Freeboard space
  - (a) Allows for expansion of bed during backwash
- (7) Regenerant tank
- (8) Multiport valve
  - (a) Controls the direction of flow through the unit
- (9) Rate of flow indicator
- (10) Rate of flow controller
- (11) Piping
- (12) Meters

Cycles of Operation

While the exchanger is removing unwanted ions it is in SERVICE, but as the ions are being replaced the unit will become exhausted and must be regenerated. The term REGENERATION does not mean only the regeneration cycle, but all the cycles during the recharging process. These cycles are all of equal importance. If one of these cycles is not completed correctly, the unit as a whole will not function properly.

Three methods are used to determine when an exchanger should be regenerated. They are:

1. Time(shift, daily, biweekly)
2. Quantity (number of gallons produced)
3. Quality of water (test for exhaustion)

TIME. At some installations the amount of water used per day is fairly constant. It is important that service not be stopped for regeneration. The size and capacity of the ion exchange equipment are planned so that servicing is done at night, on weekends, or between shifts. Regeneration is done regardless of the state of exhaustion. Many fully automatic units are controlled by clocks that start the regeneration process after work days but not on weekends.

QUANTITY. At some installations the regeneration is done during the work day when it is needed. Probably the most dependable control device in this case is the water meter. The volume of water that the unit is expected to process is determined by the manufacturer and by operating records. The water meter is set to sound an alarm or to start regeneration when a certain number of gallons have been processed.

In the automatic system, the water meter is equipped with an electric contact head to start automatic regeneration. In the manually operated type, the meter may be connected to an electrical contact which will ring a bell or flash a light and thus indicate the need for regeneration.

QUALITY OF WATER. Monitoring of product quality is desirable because it allows an operator to produce the maximum amount of water from each regeneration and also insures good quality of water for the using agency. Cation exchangers may be tested for exhaustion by conducting the total hardness test (either EDTA or soap test). Demineralizers are usually monitored with a conductance meter. When TDS exceeds a specified limit, the exchanger must be regenerated.

There are four (4) steps in the regeneration process:

BACKWASH is a very important step of operation, because foreign matter has a tendency to act as a plug which restricts the flow of water. It also reduces the exchange capacity of the resin as it coats the resin beads. Channeling and clumping are broken up and the resin is prepared for chemical treatment. It is a good practice to place a beaker or large mouth container beneath the backwash outlet to observe the waste water for any resin that is being backwashed from the column and for determining when backwash water becomes free of turbidity.

CHEMICAL INJECTION. This is the chemical treatment in which the unwanted ions are removed through "mass action." A high concentration of chemical reverses the normal ion exchange action, allowing the resin to be returned to the original condition. The chemical used depends on the type of exchanger and resin.

SLOW RINSE. This step allows for contact time between the resin and chemical. It allows regeneration to be completed throughout the bed.

FAST RINSE. The excess regenerant chemical and ions it has removed are washed out of the bed to waste. The rinse should continue until the normal operating condition is reached. The exchange unit can then be returned to service.

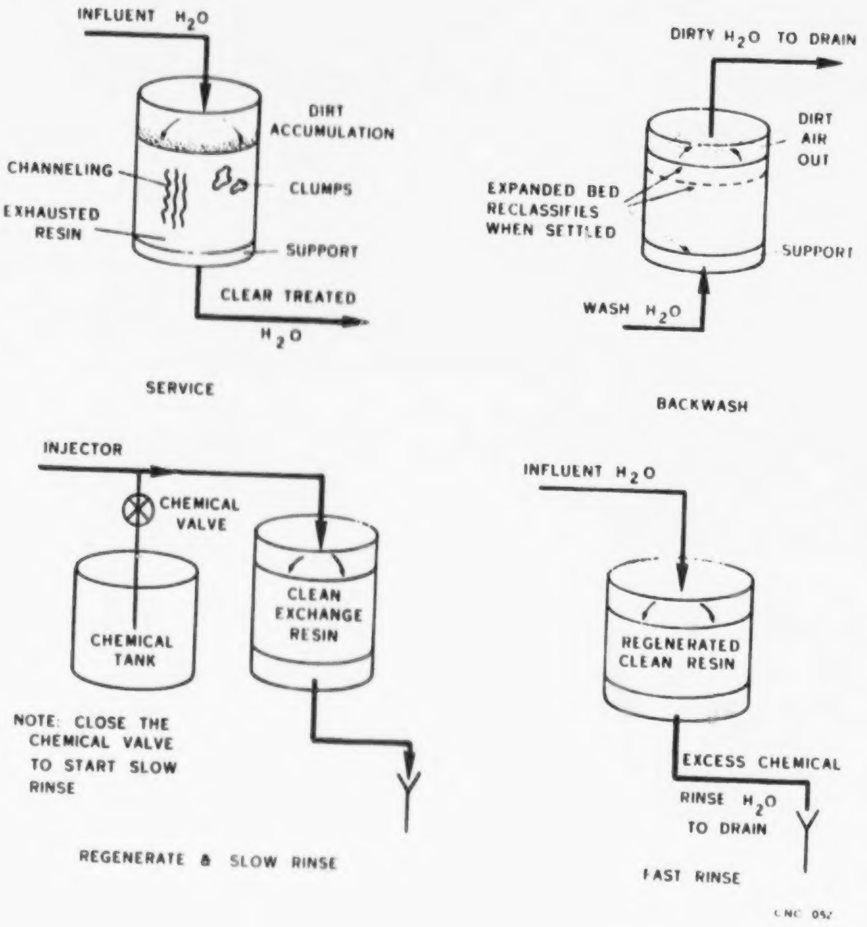

INFLUENT H_2O
DIRT ACCUMULATION
CHANNELING
CLUMPS
EXHAUSTED RESIN
SUPPORT
CLEAR TREATED H_2O
SERVICE
DIRTY H_2O TO DRAIN
DIRT AIR OUT
EXPANDED BED RECLASSIFIES WHEN SETTLED
SUPPORT
WASH H_2O
BACKWASH
INJECTOR
CHEMICAL VALVE
CHEMICAL TANK
CLEAN EXCHANGE RESIN
NOTE: CLOSE THE CHEMICAL VALVE TO START SLOW RINSE
REGENERATE & SLOW RINSE
INFLUENT H_2O
REGENERATED CLEAN RESIN
EXCESS CHEMICAL
RINSE H_2O TO DRAIN
FAST RINSE
CNC 052

Figure 4-7. Regeneration Cycle

EXERCISE III-4-4ad

PART 1

INSTRUCTIONS: On the shell of the unit in figure 4, show the approximate location of the following items. Match the letter preceding the listed item to the numbered arrows to show their location on figure 4. Items may be used once, more than once or not at all.

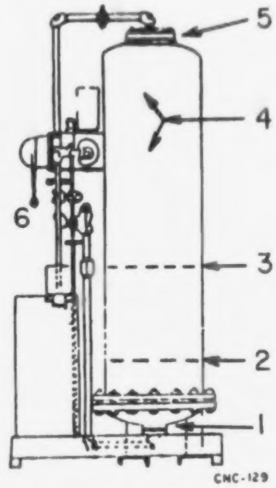


Figure 4-8. Cation Tank on Demineralizer Unit

TERMS

a. Top of ion exchange material bed.

b. Influent distributor.

c. Multiport valve.

d. Anthracite coal bed - support bed for exchange material.

e. Free board space.

f. Rate-of-flow controller.

g. Underdrain system.

h. Pressure relief valve.

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

_______Instr initials

PART 2

INSTRUCTIONS: On the shell of the unit in figure 4-9, show the approximate location of the following items. Match the letter preceding the listed item to the numbered arrows to show their location on figure 4-9. Items may be used once, more than once or not at all.

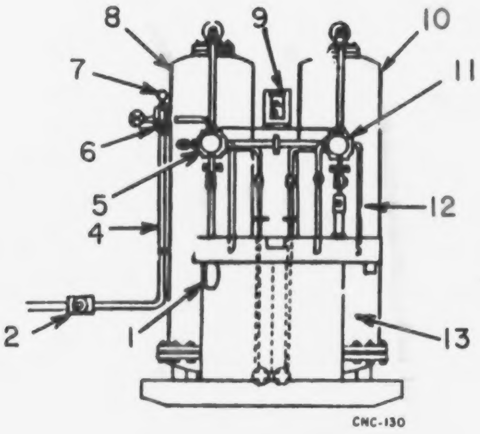


Figure 4-9. Dual Bed Demineralizer

a. Cation exchange unit

b. Anion exchange unit

c. Acid regenerant tank

d. Multiport valve

e. Flow rate meter

f. Caustic regenerant tank

g. Underdrain system

h. Conductivity meter and controller

i. Raw water influent line

j. Effluent line from cation and anion tanks

k. Collection trough

l. Pressure gauge

m. Rate controller

-------------- STOP -----------------------

Before proceeding any further, have the instructor check your work.

______Instr initials

EXERCISE III-4-4b

INSTRUCTIONS

Complete the following questions. You may consult the instructor if you have any questions.

1. The two anion exchange resins are ________________ and ________________.

2. Two functions of the underdrain are ________________ and ________________.

3. The ______________ controls the direction of flow through the unit.

4. ________________ acids are removed by a weakly basic anion exchanger.

5. The two resins in a mixed-bed demineralizer are ____________ and ____________.

6. The dual-bed demineralizer is composed of a ______________cation unit and ________________ anion unit.

7. ______________ is used to regenerate a sodium zeolite softener, ____________ is used for a hydrogen zeolite softener, and ________________ is used for a strong base anion unit.

8. A ____________ will remove strong acid only.

9. The effluent from a ____________________ is acidic.

10. A ______________________ will remove all acids.

11. The __________________ phase of operation follows chemical injection.

12. During chemical injection the unwanted ions are removed through ________________ ____________________.

13. The __________________ phase allows for contact time between the resin and regenerant chemical.

INFORMATION

MONITOR/OPERATE AN ION EXCHANGE SOFTENER AND DEMINERALIZATION UNIT

Water Softener

SODIUM ZEOLITE. When hard water is passed through a bed of active sodium zeolite, the calcium and magnesium ions are taken up by the zeolite and at the same time the zeolite gives up sodium ions.

The process of ion exchange is reversible. When the zeolite gives up all of its sodium in exchange for calcium and magnesium, it is said to be exhausted. In order to regnerate the zeolite, the bed is backwashed, then regenerated with salt water. The sodium ions from the brine solution recombine with the zeolite, which then gives up calcium and magnesium ions which combine with chloride.

Calcium and magnesium chloride are soluble salts and are rinsed from the zeolite bed with clean water. Following regeneration, the exchange material is ready for another run to soften water.

DEMINERALIZERS

Demineralization is the process of removing inorganic salts from water by ion exchange. Only those substances which ionize in water can be removed by this process. Demineralization involves two ion exchange reactions that are carried out with the use of two types of ion exchange materials. One material removes the cations and the other removes the anions from the water.

The operator should test the product for quality with the conductivity meter and check the meter on the unit by comparing the readings. It may be necessary to convert the readings from OHMS to MICRO-MHOS or MICRO-MHOS to OHMS. See Table 1 for conversion values.

Micro-Mhos/Cm Conductance	Ohms/Cm Resistance	p.p.m. as NaCl	p.p.m. as $NaCO_3$ Strong Base
0.5	2,000,000	0.0	0.0
1.0	1,000,000	0.3	0.2
2.0	500,000	0.6	0.4
3.0	333,000	0.9	0.6
4.0	250,000	1.5	0.8
5.0	200,000	2.0	1.0
10.0	100,000	4.5	2.0
20.0	50,000	9.5	4.0
30.0	33,000	14.2	6.0
40.0	25,000	19.0	8.0
50.0	20,000	23.6	10.0
100	10,000	47.7	20.0
200	5,000	95.0	40
300	3,330	143	60
400	2,500	200	80
500	2,000	239	100
1,000	1,000	503	200
2,000	500	1,000	400
3,000	330	1,000	600
4,000	250	2,065	
5,000	200	2,650	
7,500	133	3,970	
10,000	100	5,430	
20,000	50	11,500	

$$\text{Micro-Mhos} = \frac{1,000,000}{\text{ohms}} \qquad \text{ohms} = \frac{1,000,000}{\text{Micro-Mhos}}$$

$$\text{GPG} = \frac{\text{p.p.m.}}{17.1} \qquad \text{GPG} = \text{p.p.m.} \times 0.0584$$

Table 1 - Conductance Conversion Values at 25°C

BACKWASH OF CATION COLUMN. Backwash is a very important step of operation, because foreign matter has a tendency to act as a plug which restricts the flow of water. It also reduces the exchange capacity of the resin as it coats the resin beads. Figure 1 shows foreign matter being coated onto the resin beads. Figure 2 shows the backwash cycle removing the deposits from the beads. From observing figures 1 and 2, you can see why backwashing is an important step in the operation of demineralizers.

It is a good practice to place a beaker or large mouth jar beneath the backwash outlet to watch the waste water for any resin that is being backwashed from the column and to see when backwash water becomes free of turbidity.

CHEMICAL INJECTION FOR CATION COLUMN. When the regeneration cycle is initiated, the cations which have been removed by the resin are exchanged for new hydrogen cations from sulfuric acid (H_2SO_4). It is important to remember that each column, the cation and the anion, are regenerated and rinsed separately.

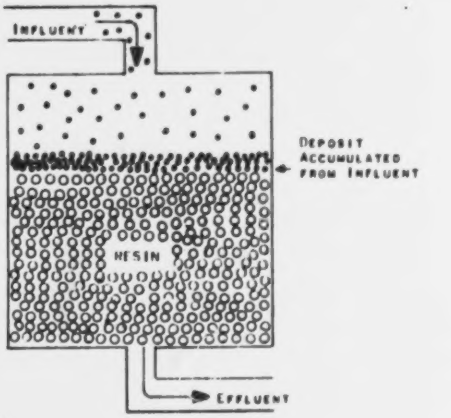


Figure 1 - Deposits Forming a Coating on Resin Surface

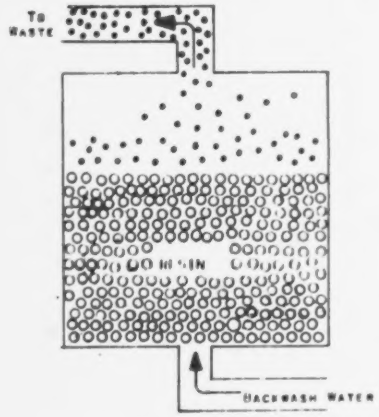


Figure 2 - Deposits Being Removed from Resin Surface by Backwashing

A word of caution: Baume 66° (H_2SO_4) and flake caustic soda (anion regenerant) are both dangerous materials to handle and work with. A person could receive severe burns from either of these chemicals if the proper precautions are not used. Use all safety equipment at your disposal. This equipment should consist of acid-proof apron, gloves, goggles, and footwear.

After the backwash cycle has been completed, the next cycle is chemical injection. To regenerate the cation bed, the acid is prepared and used according to the following procedure.

1. Fill acid tank partially with water.
2. Measure the exact amount of acid required.
3. Slowly pour acid into the water while stirring constantly.
4. Add make-up water to the recommended tank level.
5. By following the manufacturer's instructions, open and close the correct valves and start the water flow at the prescribed rate for the regeneration step.
6. Continue this phase of regeneration until the correct amount of acid has been pulled from the tank.
7. After regeneration has been completed, rinse the acid tank to prevent an unsafe condition.

Figure 4-10 illustrates the regeneration cycle of a cation unit.

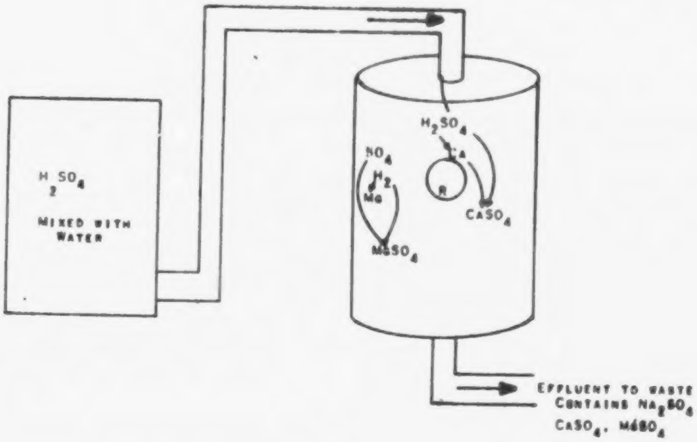


Figure 4-10 - Regeneration with H_2SO_4

The last step in the regeneration cycle of the cation column is the slow and fast rinse cycles. The slow rinse completes regeneration and fast rinse removes excess acid or bases left by the regenerating material. By all means, follow the manufacturer's instructions for operation of demineralizers as it is impossible for this student text to contain all information pertaining to each type of demineralizer being used throughout the Air Force.

REGENERATION CYCLE FOR ANION COLUMN. Regeneration cycle of the anion column is similar to the regeneration cycle of the cation column.

ANION BACKWASH. The water flows upward through the resin to remove dirt and air and loosen or reclassify the bed. The flow rate must be slower than for cation resin because the anion resin is lighter and will wash out easier.

CHEMICAL INJECTION (NaOH). The procedure for mixing flake caustic is the same as for sulfuric acid.

CAUTION: The dust of flake caustic is very active and will burn your eyes and respiratory system.

1. Partially fill caustic tank with water.

2. Measure exact amount of liquid or flake caustic soda.

3. Slowly add NaOH to the water in the tank and stir until dissolved.

4. Fill caustic tank to recommended level.

5. Inject caustic solution at proper flow rates. NOTE: DO NOT stir after injection has started.

6. Rinse caustic tank after regeneration is complete.

SLOW RINSE. After all the caustic has flowed into the resin, the same flow rate is continued to complete the regeneration of all parts of the bed.

FAST RINSE. Fast rinse removes the excess caustic. The flow rate is set near the maximum service flow rate.

The conductivity meter is set at the lowest quality water that is acceptable. When the meter lights change, the rinse is complete; and the water is ready for service.

Mixed Bed Demineralizers

Also known as the mono-bed, this unit has hydrogen cation and strong base anion mixed through the entire bed depth.

BACKWASH. When test for exhaustion shows that unit needs regenerating, resins must first be separated by thorough backwashing. The lighter anion resin will come to the top while the cation resin remains at the bottom. After separation is complete, the column is ready for regeneration.

CHEMICAL INJECTION: A flake caustic soda solution (anion regenerant) and muriatic acid solution (cation regnerant) must be prepared for regeneration. Both are dangerous materials to work with. All safety and protective clothing should be worn while working with these chemicals. During regeneration the acid flows upward through the cation resin and out to waste. The caustic soda flows downward thorugh the anion resin and out to waste.

SLOW RINSE. Flow is continued to allow contact time between regenerant chemical and resins.

AIR MIX OF RESINS. Resins are mixed together by means of compressed air. A mild agitation is all that is necessary.

FINAL RINSE. A final rinse is applied to the mixed resins before the unit is put back into service. When minimum conductivity is reached, the unit is ready to be put back into service.

Instructions for monitoring/operating the different types of ion exchangers follow. You will operate each type of exchanger by following the checklist with instructor supervision.

EXERCISE IV-4a (3)

Instructions

Follow the instructions below for operation of the water softener trainer, water softener, dual bed demineralizer and mixed bed demineralizer. Each item of guidance is important for proper operation and the steps listed should be followed in the order presented.

OPERATION OF WATER SOFTENER

SAFETY PRECAUTIONS

1. This trainer is designed to teach the flow and physical operation of ion-exchangers during different phases of operation. It is recommended that chemicals NOT be used under classroom conditions. If regeneration is desired, use NaCl only.

2. Never allow water pressure in unit to exceed 20 psi.

3. When changing cycles, the hardwater inlet valve should be opened last and closed first to prevent excess pressure in system.

PREOPERATIONAL CHECKS

NOTE: Check schematic for location of valves and lines.

1. Check all valves.

2. Check pressure regulator for a system pressure of 15 to 20 psi and adjust if required.

3. If the water level in the ion-exchange tank is more than one inch below the top of the tank, fill and purge air as follows:

   a. Open both backwash valves.

   b. Open hardwater inlet valve just enough to allow water to fill tank but not enough to cause expansion of bed.

c. When water reaches the distributor in the top of the tank, close the hardwater supply and backwash valves.

4. If water level in the brine tank is lower than 3/4 full, fill to desired level as follows:

a. Open the service valve, drain line, brine outlet valve, and hardwater inlet valve.

b. When the 3/4 full level is reached, close ALL valves, starting with the hardwater inlet valve.

5. If the trainer has been shut down for an extended period of time, place it in fast rinse for a short period of time before placing the trainer in service.

NOTE: See fast rinse procedures under Operating Sequence in this study guide/workbook.

OPERATING SEQUENCE

1. Place the unit in service as follows:

a. Open service valve, softwater valve, and hardwater inlet valve.

b. If softwater tank is over 3/4 full, open softwater drain valve enough to prevent overflow from top of tank.

2. Backwash the bed as follows:

a. Close all valves, starting with the hardwater inlet valve.

b. Open both backwash valves.

c. Open the hardwater inlet valve slowly until the bed expands approximately 50 percent.

CAUTION: An excessive backwash rate will cause zeolite to be washed to the drain. Backwash for one minute.

d. Stop backwash by closing all valves, starting with the hard-water inlet valve.

3. Place unit in the Chemical Injection Phase as follows:

a. Open brine injection valve, drainline valve, and hardwater inlet valve.

b. Open brine outlet valve. When 1 to 2 inches of chemical has been drawn from the brine tank, go to step 4.

4. Slow rinse the bed as follows:

a. Stop chemical injection, step 3b above, by closing the brine outlet valve. This places the unit in slow rinse.

b. Stop slow rinse by closing brine injection valve. Leave other valves as they are.

5. Fast rinse the bed as follows:

a. Following step 4b above, open service valve. This places the unit in fast rinse.

b. To place the unit into service at the end of fast rinse, open softwater valve and close drain line.

POSTOPERATIONAL CHECKS

1. Check valves and tanks for leaks and cracks.

2. Close all valves except the backwash valve to drain.

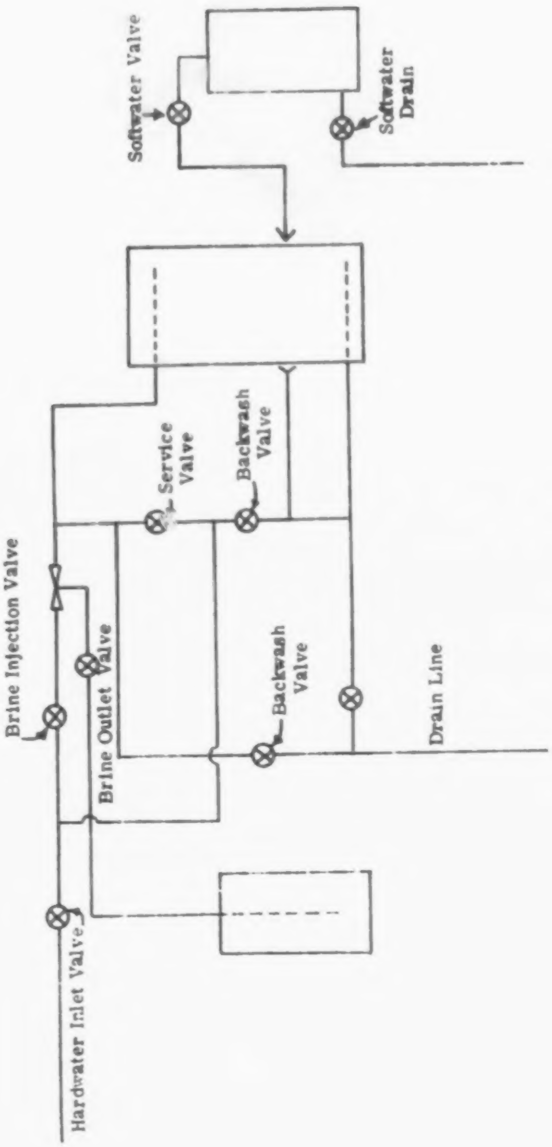

Softwater Valve
Softwater Drain
Service Valve
Backwash Valve
Brine Injection Valve
Brine Outlet Valve
Backwash Valve
Drain Line
Hardwater Inlet Valve

Figure 4-9. Schematic of Water Softener Trainer

OPERATION OF THE DUAL BED DEMINERALIZER

NOTE: Trace flow of water during each cycle and name each component that the water passes through.

Service

1. Place the unit into service as follows:

    a. Place solo valve in service position #3.

    b. Open valve #2.

    c. Open valve #1, the hardwater inlet valve and adjust to a maximum flow of 6 GPM.

2. Assume the bed is exhausted. Regenerate unit.

Preparing Regenerate Solution

NOTE: This step can be omitted if the brine tank contains four or more inches of brine solution. Furthermore, there should be undissolved salt in the bottom of the tank.

1. For each four inches the brine level is below its upper level in the tank, add 15 pounds of salt to the brine tank. For example, if the brine is eight inches low, add 30 pounds of salt.

2. Place solo valve in service position No. 3. Valve No. 1 should be open.

3. Open valve No. 4 and add water up to the "upper brine level", then close.

Regenerating Sodium Zeolite Unit

1. Backwash (Step No. 1)

    a. Close valves No. 1 and No. 2.

    b. Open valve No. 3 momentarily to release pressure in tank and then close.

    c. Place solo valve on BACKWASH, position No. 1.

    d. Control influent by valve No. 1 at 2 GPM for 5 minutes, then close.

2. Regeneration (Step No. 2)

    a. Adjust solo valve for chemical injection and slow rinse in position No. 2.

    b. Open valve No. 1. Flow rate is controlled by the solo valve.

    c. Open valve No. 4 to permit addition of salt brine to water going through the resin column. Total brine drawdown is four inches and usual time is about 4 minutes.

    d. Close valve No. 4 when regeneration is completed.

3. Slow Rinse (Step No. 3)

    a. Four minutes after valve No. 4 is closed, begin the slow rinse. Continue slow rinse for 7.5 minutes.

    b. Close valve No. 1 after the 7.5 minutes.

4. Final Rinse (Step No. 4)

   a. Place solo valve in service position No. 3.

   b. Fully open valve No. 3.

   c. Open valve No. 1 to give a flow of 2 GPM.

   d. Rinse until salt cannot be tasted in effluent and then close valve No. 3.

5. Service Run (Step No. 5)

   a. Open valve No. 2 on service line.

   b. To adjust to the desired maximum flow:

      (1) Open valve No. 3.

      (2) Using valve No. 1, adjust the desired maximum flow of 3 gpm.

      (3) Then close valve No. 3. This places the ion exchanger back in service.

The manual operation of the demineralizer during regeneration will be in four cycles.

1. Backwash

2. Regeneration (chemical injection - slow rinse)

3. Fast Rinse

4. Service

To obtain these four cycles of operation requires the following steps. Perform these steps under the supervision of the instructor.

Note that all operations, except the final rinse, are conducted separately on each column. The valves of this unit are numbered to coincide with the following instructions:

STEP 1 - SERVICE

1. Solo-valve No. 1 in "Run" position (Position No. 3)

2. Solo-valve No. 2 in "Run" position (Position No. 3)

3. Open valve No. 13 on service line

4. Control flow with valve No. 9 to 1.5 GPM, maximum 2 GPM

5. Perform test for exhaustion. If bed is exhausted, regenerate unit

STEP 2 - SHUTDOWN (End of service run prior to regeneration)

1. Solo-valve No. 1 in "Run" position (Position 3)

2. Solo-valve No. 2 in "Run" position (Position 3)

3. Close valve No. 9 and No. 13

4. Open valve No. 12

5. Solo-bridge switch to "Off" position

STEP 3 - BACKWASH

NOTE:
- a. Start backwash SLOW, increase gradually to prescribed rate.
- b. Always have sampling jar under solo-valve drain line; if resin particles are being discharged, reduce rate.
- c. Continue backwashing until water is clear and free of suspended matter.
- d. Anion column first, cation column second.

Anion Column:

1. Solo-valve No. 1 in "Run" position (Position No. 3)
2. Solo-valve No. 2 in "Wash" position (Position No. 1)
3. Open influent valve No. 9 and backwash at a rate of one (1) gallon per minute for ten (10) minutes (or until effluent is clear).
4. Close valve No. 9 at end of backwash.

Cation Column:

1. Solo-valve No. 1 in wash position (Position No. 1)
2. Solo-valve No. 2 in run position (Position No.
3. Open influent valve No. 9 and backwash at a rate of two (2) gallons per minute for five (5) minutes (or until effluent is clear).
4. Close valve No. 9 at end of backwash.

STEP 4 - REGENERATION (Simulate injection of chemicals)

CATION: Wear protective clothing to guard against splashing of chemicals.

NOTE:
- a. Both columns are regenerated and rinsed separately before the final rinse.
- b. The anion column should be regenerated each time the cation column is regenerated.

Chemicals Required:

1. Cation - H_2SO_4 (66°Be) 7.5 lb
2. Anion - NaOH (flake) 6.0 lb

Preparation of Regenerant Solutions:

Acid Tank (Cation bed)

1. Solo-valve No. 1 and solo-valve No. 2 in Run position (position No. 3), all other valves closed.
2. Open influent valve No. 9. Open valve No. 5, add water until level is 20 inches from top. Close valve No. 9.
3. Add required amount of acid directly to acid tank and mix.
4. Open valve No. 9 and add water until level of solution is 2 inches from top of tank, then close valve No. 9.

Caustic Tank (Anion bed)

1. Solo-valves No. 1 and 2 in run position (position 3); all other valves closed.
2. Open valves 6 and 9.
3. Add required amount of NaOH slowly, stirring constantly.
4. Fill tank with water until level of solution is 10-1/2 inches from top.
5. Close valve No. 9.

Regeneration of Units:

Cation Regeneration

1. Solo-valve No. 1 in chemical injection position (position No. 2)
2. Solo-valve No. 2 in run position (position No. 3)
3. Open and adjust influent valve No. 9 for a flow rate of 0.75 GPM (approximately 30 PSI)
4. Open acid valve No. 5.
5. Close acid valve No. 5 when liquid level is 2 inches from bottom of tank (suction time approximately 42 minutes)

Cation Slow Rinse

1. Solo-valve No. 1 in chemical injection position (position No. 2)
2. Solo-valve No. 2 in run position (position No. 3)
3. Rinse at 0.75 GPM for 7.5 minutes (22.5 gal)
4. Close valve No. 9 at end of 7.5 minutes

Anion Regeneration

1. Solo-valve No. 1 in run position (position No. 3)
2. Solo-valve No. 2 in slow rinse position (position No. 2)
3. Open and adjust influent valve No. 9 for a flow rate of 0.75 GPM (approximately 30 PSI)
4. Open caustic valve No. 6
5. Close caustic valve No. 6 when solution level is 2 inches from bottom of tank. (Suction time approximately 17 min.)

Anion Slow Rinse

1. Solo-valve No. 1 in run position (position No. 3)
2. Solo-valve No. 2 in slow rinse (position No. 2)
3. Valve No. 12 wide open.
4. Valve No. 9 remains open and controls rinse at 0.75 GPM for 5 minutes
5. Close valve No. 9 at end of 5 minutes.

STEP 5 - FINAL RINSE

1. Solo-valve No. 1 in run position (position No. 3).
2. Solo-valve No. 2 in run position (position No. 3).
3. Valve No. 12 WIDE OPEN.
4. Set "pointer" of solu-bridge at 50,000 OHM, adjust temperature rheostat at temperature of effluent, turn switch "ON".
5. Open influent valve No. 9.
6. Rinse at 2 GPM until GREEN LIGHT burns continuously.
7. Open valve No. 5 and valve No. 6 for 10 seconds each during rinse to flush out lines.

STEP 6 - SERVICE RUN

1. Solo-valve No. 1 in run position (position No. 3).
2. Solo-valve No. 2 in run position (position No. 3).
3. Open valve No. 13 on service line and close valve No. 12 as soon as valve No. 13 is opened.
4. Control flow with valve No. 9 to 1.5 GPM, MAXIMUM 2 GPM.

Start-up After Shut Down

If unit has been shutdown overnight or longer, a short rinse is recommended before proceeding. (Step No. 3, Final Rinse)

End of Service Run

When red light shows continuously, the unit is exhausted. Begin again with Step 2 Shut Down, and repeat above procedure.

EXERCISE IV-4b

INSTRUCTIONS

OPERATION OF THE MIXED BED DEMINERALIZER

Normal Operation

1. Open valves E, A, and H with instructor assistance.

2. Check water pressure on the gauge PSI. It should read between 20 and 30 psi.

3. Check water purity by pressing the ohmmeter button. Any reading above 1 million is good OHM. If below 1 million, regenerate unit.

4. Let unit run for approxiamtely 5 minutes.

To Shutdown Operation

1. Close valves H, A, and E.

2. Close the main ion exchange water supply valve.

3. Shut down the cation unit you are using and relieve the pressure in the unit with instructor assistance.

Regenerate if exhausted. If not exhausted the instructor will explain the backwash and separation procedures as follows:

1. Backwash and separate

Close all valves except (B) an (V). These valves should be full open. Open valve (H) until a trickle of water comes out of the drain pipe.

After five minutes of this slow flow rate observe the resin. If there is a slow movement of the resins in a upward surge, the flow rate is fast enough. However, if there is no apparent movement in the resin bed, increase the flow rate by adjusting valve (H). It is very important that the flow rate is not excessive as it will drive the resin bed completely to the top of the column, thereby causing a plug that will not separate. If this occurs, the resin bed will have to be driven down. This is easily accomplished by closing all valves except (A), (H), and (E). When slug of resins is driven down, proceed with backwash and separate cycle for 15 minutes.

2. Regeneration of the Cation and Anion Resin

Preparing the regeneration solutions - fill a 3-gallon rubber bucket with 2 gallons of softened or demineralized water and stir in 5 pounds of caustic flakes, stirring until thoroughly dissolved. One gallon of 30 percent muriatic acid is used full strength for the cation regenerant.

Drawing Up Anion Regenerant

All valves closed, open valves in this order (C) and (C'). Slowly open valve (H) until the pressure gauge shows 15-20 pounds. Open valve (K) full. This regenerant cycle should take at least 20 minutes to allow contact time with the anion resin. Adjust valve (H) accordingly. Close all valves.

3. Rinsing

All valves closed. Open valves in this order (H), (A), and (K). Continue in this cycle for 20 minutes or until pH of the drain effluent is approximately 8-9. Close all valves.

4. Regenerating Cation Resin

All valves closed. Place acid draw-up tube in muriatic acid. Open valves in this order: (D'), (D), (K), and (H). Adjust valve (H) so that acid draw-up takes 10-15 minutes. When acid is drawn up, close valves (D') and (D). Open valve (B), readjust valve (H) to slightly increase the flow rate. Rinse cation resin in this position for 10 minutes. Close all valves.

5. Air Mixing of the Resins

(1) To drain water level to approximately 4" above resin bed:

All valves closed. Open valves (V) and (E). When water level is reached, close (V) and (E).

(2) Open valves (B), (V), and open valve (J) slowly until agitation of the resin bed starts. A mild agitation is all that is necessary. Observe resin for complete mix. This cycle will take approximately 4 minutes. Close all valves.

NOTE: If resin bed appears too dry and not mixing, add water properly by opening valve (H).

6. Final Rinsing

Fill the tank by backwashing rapidly, open valves (V), (B), and (H), to drive the bed down. Close (V), (B) and (H). Open valves in this order: (A), (H), and (E). Turn on conductivity meter. When minimum conductivity is reached, turn on (F) and close (E). Unit is now in service.

Flow control can be adjusted by valve (H) up to 120 gph or wide open.

NOTE: If unit shows preliminary exhaustion, go through the air mixing cycle. This usually adds about 20 percent more to the run cycle.

DEMINERALIZATION

INSTRUCTIONS

Answer the following questions pertaining to the operation of a mixed bed demineralizer.

1. What type of resin is used in a dual bed?

a. ____________________

b. ____________________

2. What test is performed for the exhaustion of the dual bed? ____________________

____

3. What chemicals are used for regenerations?

a. ____________________

b. ____________________

4. What is the purpose of the slow rinse cycle? ____________________

____

____

5. What is the purpose of the fast rinse cycle? ____________________

____

____

6. What is the allowable free-board space required for regeneration? ________________

____

7. What are the two cycles of operation of the mixed bed demineralizer?

a. ____

b. ____

8. Which step does chemical injection occur? ________________

____

9. Which valve is closed first and opened last? ________________

____

10. What would cause the loss of resin during the backwash cycle? ________________

____

INFORMATION

MAINTENANCE OF ION EXCHANGERS

Daily and routine inspections are a must on demineralizer equipment to keep the plant operating. Most failures can be prevented by simple inspection and spotting trouble before it gets out of hand. Water softener and demineralizer units used by the Air Force are commercially manufactured by various companies. Manufacturer's manuals should be referred to for specific units. However, AFR 91-26, Par 6-381 can be consulted for general information.

EXERCISE III-4-4c

INSTRUCTIONS

Using AFR 91-26, answer the following questions.

1. In a softener unit, how much undissolved salt should be kept in the brine solution?

____

2. How do you protect the brine measuring tank from corrosion? ________________

____

3. What maintenance is required on a leaking valve? ________________

____

4. What setting must the multiport valve be on when lubricating it? ________________

____

5. How hard should water be that is used for washing zeolite material? ________________

____

6. What kind of gravel should be used for the gravel bed? ____________________

____

7. What effect does temperature of raw water have on zeolites? ____________________

____

8. What is done to remove organic material including bacteria from zeolite beds?

____

9. What should the purity of the salt used for regeneration be? ____________________

____

10. How do you determine the efficiency of your equipment? ____________________

____

SUMMARY

Ions are electrically charged atoms or groups of atoms. Ion exchange is a reversible chemical reaction between ions in solution and ions in solid materials.

The process of ion exchange has been known for many years but the commercial use of the process is very recent. New uses for the materials and new materials are being developed all the time.

The common ion exchange materials are natural aluminum-silica sand, manmade aluminum-silica gel, sulfonated coal, and the plastic resins. The resins are now in most common use.

Sulfonated polystyrene will exchange cations and may be used on the sodium cycle as NaZ or on the hydrogen cycle as H_2Z. As NaZ, it will soften water by removing calcium and magnesium. As H_2Z, it will remove all cations and replace them with the H^+ ion. The hydrogen ion changes all salts to acid.

Ion exchange materials are reusable because they may be regenerated. Regeneration removes the impurities and restores the resin to its former operating state. Regeneration is achieved by "mass action" of an excess of regenerant chemical.

There are two types of anion exchange material, weakly basic and strongly basic. The weak base material will operate on the hydroxyl cycle or on the chloride cycle. The OH^- cycle is used to dealkalize boiler water.

The quality of demineralized water is checked with a conductivity meter that may be calibrated in micro-ohms or ohms.

3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

SW J3ABR56631 000-III-5

MONITOR/OPERATE AND MAINTAIN ELECTRODIALYSIS DEMINERALIZER UNIT

OBJECTIVES

Given information and an electrodialysis demineralizer unit, work as a team to monitor/operate the unit, with no more than three instructor assists.

Given information and an electrodialysis demineralizer, work as a team to maintain the unit, with no more than two instructor assists.

INTRODUCTION

ELECTRODIALYSIS DEMINERALIZATION

INFORMATION

Principles of Operation

As you know, most water is a conductor; that is, it will conduct electricity. The reason for this, is that most water is not pure. Pure water (that is, pure H_2O) will not conduct electricity. For water to conduct electricity, it must contain an acid, a base, or salt. Water containing an acid, base, or salt is called an electrolyte. When an acid, base, or salt is put in water, it breaks down into "ions." These ions are either positively or negatively charged. The positively charged ions are called cations and the negatively charged ions are called anions. For instance, when table salt (NaCl) is put in water, it breaks down into positive sodium ions (Na^+)and negative chloride ions (Cl^-) as shown in the following equation:

$$NaCl \xrightarrow{\text{in water}} Na^+ + Cl^-$$

The separation or disassociation of compounds when dissolved in water is known as ionization. When ionization takes place, there are numerous positive and negative ions floating around in the water, but the total number of positive charges in the water is equal to the total number of negative charges. Hence, the water or solution, as a whole, remains electrically neutral. Because of these electrically charged ions, water is able to conduct electricity. The more ions in the water, the more electricity it will conduct.

The most common ions found in water in appreciable quantities are as follows:

Cation		Anion	
Sodium	Na^+	Chloride	Cl^-
Calcium	Ca^{++}	Bicarbonate	HCO_3^-
Magnesium	Mg^{++}	Sulfate	$SO_4^=$

EFFECT OF DIRECT CURRENT (DC) POTENTIAL ON IONS. If a DC potential is applied across a solution of water and salt by means of two electrodes in the solution, cations will move toward the negative electrode, which is known as the cathode, and the anions will move toward the positive electrode, which is known as the anode. Figure 5-1 is a container of sodium chloride and water solution. In this solution, the sodium cations (Na^+) and chloride anions (Cl-) move about at random. Figure 5-2 illustrates the same solution with a DC potential applied to electrodes in the solution. The anions move toward the positive electrode (anode) and the cation moves toward the negative electrode (cathode).

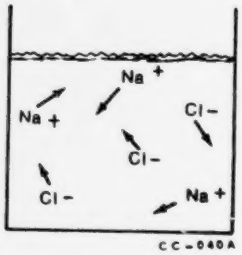
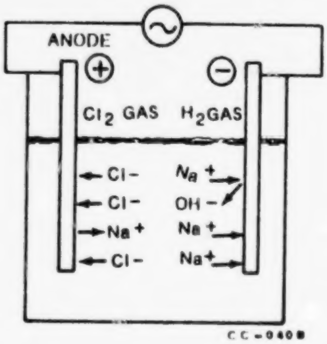


Figure 5-1. Sodium Chloride
and Water



5-2. D.C. Potential Applied
to the Electrodes

Typical natural waters contain varying amounts and types of cations and anions. When DC potential electrodes are inserted in these waters, all of the cations will move in one direction, toward the cathode; and all of the anions will move in the opposite direction, toward the anode. Thus, the area of water between the electrodes where the ions have been removed becomes the purified zone. This ion movement can be used to deionize water, if proper barriers were used to isolate the purified zone, to prevent the removed ions from reentering the purified water.

ISOLATION OF THE PURIFIED ZONE. There are two types of membranes which can be used as barriers to isolate the purified zone.

Cation Membrane. A negatively charged membrane which will permit only cations to pass through it when DC is applied to the solution.

Anion Membrane. A positively charged membrane which will permit the passage of anions only.

Three-compartment Cell. At the bottom of the unit shown in figure 5-3, the number "1" denotes the anode (positive electrode), "2" is the anion membrane (positive charge), "3" is the cation membrane (negative charge), and "4" is the cathode (negative electrode). In figure A we show no electrical flow; the switch is open. In this situation, the ions will move at random in their respective compartments represented by the letters A, B, and C at the bottom of the figure. However in figure B, we have closed the switch and introduced a current to the system. The anode electrode is positively charged and the cathode electrode is negatively charged. The cations (Na^+) move toward the cathode and the anions (Cl^-) move toward the anode. The following action occurs in each compartment.

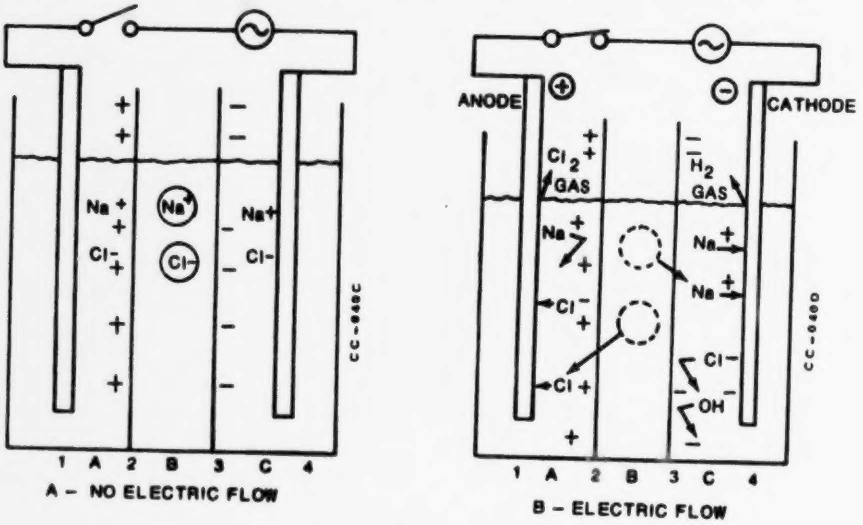


Figure 5-3 Three Compartment Cell

1. Na^+ from compartment A tends to move toward the cathode and away from the anode, but it cannot pass through anion membrane 2 into compartment B, because like charges repel each other.

2. Na^+ from compartment B passes through cation membrane 3 into compartment C and is repelled by anion membrane 2.

3. Cl^- from compartment B passes through anion membrane 2 into compartment A and is repelled by cation membrane 3.

4. H^+ from ionized water in compartment C reacts at the cathode to give off hydrogen gas and the Na^+ ion reacts with the hydroxyl ion left to form NaOH.

5. Cl^- from compartment C tends to move toward the anode and away from the cathode, but it cannot pass through cation membrane 3 into compartment B and is thus retained in compartment C.

6. Compartment B becomes the demineralized water compartment.

7. Chlorine gas is given off in compartment A due to the oxidation of chloride ion at the anode.

8. Hydrogen gas is given off in compartment C due to the reduction of the hydrogen ion at the cathode. The action will leave OH^- ions in that compartment.

The above actions, using Na^+ and Cl^-, to show the movement of the ions is not restricted to Na^+ and Cl^- but includes all positive ions (cations) such as sodium, potassium, calcium or magnesium, and all negative ions (anions) such as chloride, sulfate, or bicarbonate. Now it can be seen how the overall effect has been a demineralization of the central compartment.

If compartments A or C become too concentrated with excessive ions, they will react with the water to cause scale or corrosion. They will also plate the electrodes and polarize them.

MULTICOMPARTMENT UNIT. The electric membrane (Elec. Mem.) process can be used to remove all types of ions (both ion salts and ion minerals) from water by the use of the migration of the ions through an ion transfer membrane (in a direct current electrical field.) These types of ion membranes are very selective as to which ions they let pass. Some of them will pass only positive ions and some of them will pass only negative ions.

To be of any use, the capacity of the unit must be enlarged. To do this, we add alternating cation and anion membranes between the electrodes. This type of unit is shown in figure 5-4. There are five anion compartments and six cation compartments.

The negative electrode (cathode) is at the bottom of figure 5-4. Due to its negative charge, all cations (positive charges) will be attracted to it and will try to move down. However, only those cations whose lower boundary is a cation membrane (compartment 2, 3, 5, 7, 9 and 10) can move down. These cations can move only one compartment after passing through the cation membrane. Cations cannot pass through an anion membrane and are repelled away from the anode. The cations are not stuck to the membrane but are trapped in the compartment. Water forced to flow through the concentrate streams will wash the cations out of the unit.

In a like manner, the positive electrode will attract all of the anions in an upward direction. All the anions with anion membranes above them (compartment 3, 5, and 7) will be able to move up one compartment. After they pass through the anion membrane, the next membrane which is a cation membrane will stop any further travel of the anions. These anions have no desire to move downward due to the repelling force of the cathode. The concentrate streams will also remove these anions at the same time they are removing the cations.

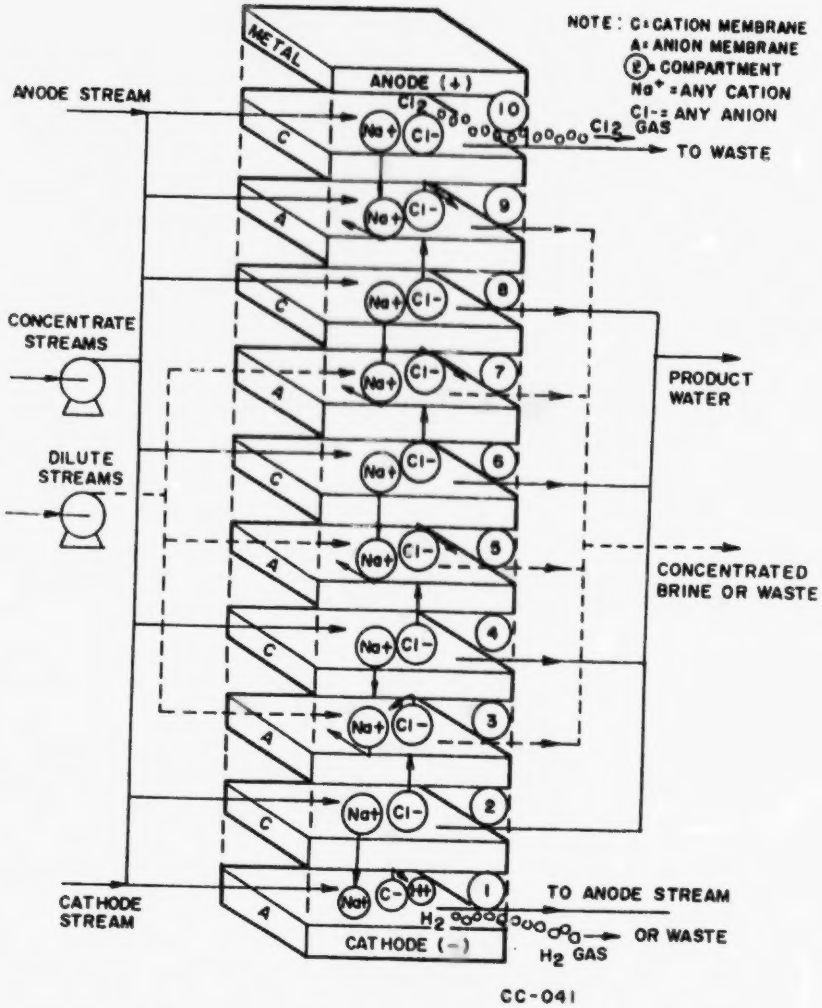

NOTE: C=CATION MEMBRANE
A=ANION MEMBRANE
②=COMPARTMENT
Na+=ANY CATION
Cl-=ANY ANION
METAL
ANODE (+)
ANODE STREAM
Cl2
Cl2 GAS
TO WASTE
C
A
Na+
Cl-
10
9
8
7
6
5
4
3
2
1
CONCENTRATE STREAMS
DILUTE STREAMS
PRODUCT WATER
CONCENTRATED BRINE OR WASTE
CATHODE STREAM
TO ANODE STREAM
OR WASTE
H2
H2 GAS
CATHODE (-)
CC-041

Figure 5-4. Multicompartment Unit

At the bottom of the unit, compartment 1 (with the cathode) will keep the anions and will gain cations. In this way, as long as the brine flows through the unit, compartment 1 will continually gain cation concentration and introduce a dilute brine solution. This flushing may also stop the precipitation of salts which would have a tendency to coat the cathode itself and partially plug the cation membrane to the right. At the same time that this action is taking place, the cathode is also attracting positively charged hydrogen ions to it. These hydrogen ions get an electron from the cathode and when two of these neutralized hydrogen atoms contact each other, they form a molecule of hydrogen gas, precautions should be taken here to prevent fire hazards due to the burning properties of hydrogen gas.

Hydrogen, when vented, leaves behind it a hydroxide (OH^-) ion. It is this ion which may control the rate or the frequency at which we must flush out the compartment. As magnesium and/or iron are positively charged ions, they will be attracted to the negatively charged hydroxide (OH^-) ion. Once contact is made between these positively and negatively charged ions, due to the low solubility of the resulting compound, a precipitate is formed, as shown below.

$$Mg^{++} \quad + \quad 2(OH)^- \longrightarrow Mg(OH)_2 \quad |$$

$$Fe^{+++} \quad + \quad 3(OH)^- \longrightarrow Fe(OH)_3 \quad |$$

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Component of Unit

If you know the purpose and function of each component of a system, it then becomes easier to understand the operation of the system as whole. The operation of the system is to be considered, but first we will identify and discuss the function of its various components.

The E.D. unit is designed to produce 500 gallons of product water with a maximum of 500 ppm total dissolved solids (TDS), and 600 gallons of waste water. It is designed to operate with a feed-water supply pressure of 45 psi minimum and 65 psi maximum, and a product flush water pressure of 15 psi minimum and 65 psi maximum, and with a temperature of 50°F.

Its electrical characteristic is 110 volts, single phase, 60 Hertz with a total connected load of 750 V.A.

MECHANICAL COMPONENTS. The following items are the E. D. system mechanical components and their functions. (See foldout 1 for location of components in the unit.)

1. Hand operated Plug Valve (PV-1) in the raw feedwater supply and product flush water lines. When open, they hydraulically connect the E. D. system to the raw feedwater supply and product flush water.

2. Cartridge Filter (CF-1) removes suspended material from the raw water.

3. Cartridge Filter (CF-2) removes chlorine, if present, from water prior to it entering the membrane stack.

4. Pressure Gauges (PG-1, PG-2, and PG-3) show the pressure across the filters.

5. Solenoid Valve (SOV-1) start and stop raw feedwater supply to the unit during automatic operation.

6. Solenoid Valve (SOV-2) opens for a preset period of time when the unit stops producing water. (It is automatically controlled by the water level in the storage tank.) The purpose is to flush and purge the system of high concentrations and goes before a prolonged shutdown.

7. Pressure Reducing Valve (PRV-1) maintains preset pressure at the membrane stack to compensate for fluctations in line pressure and pressure drop across the filters.

8. Pressure Gage (PG-4) shows stack inlet pressure.

9. Membrane stack (S-1) for water desalinizatin.

10. Solenoid Valves (SOV-3 and SOV-4) switch product and waste water streams with the polarity reversal of the membrane stack.

11. Product water rotameter (Fl-1) shows desalted water flow rate in gpm.

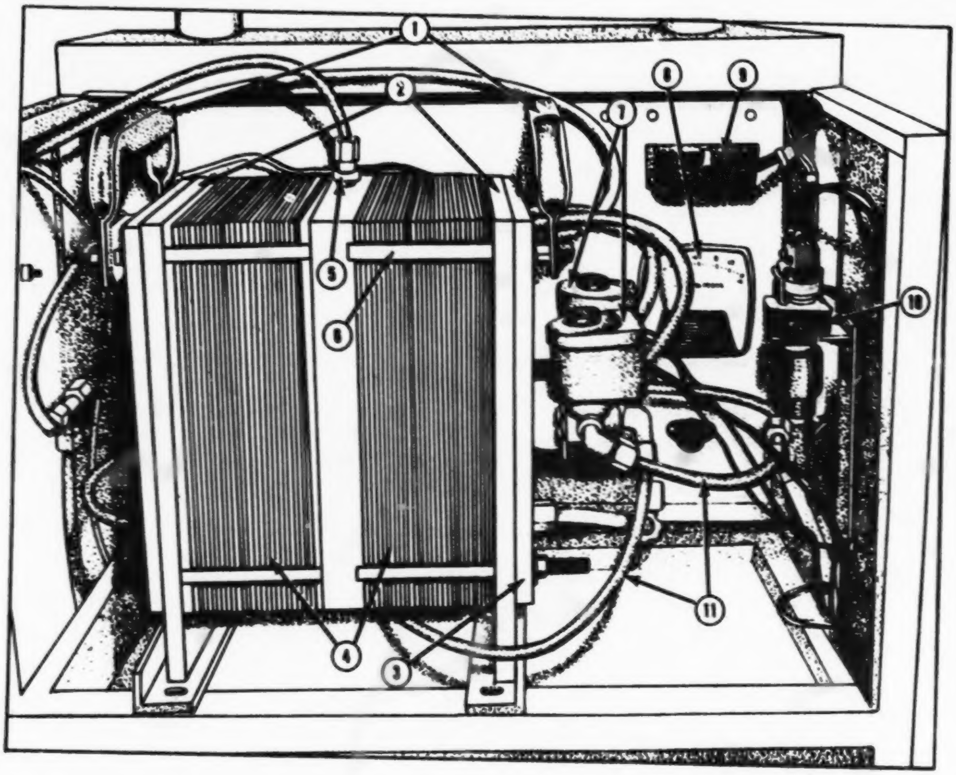
12. Waste holdup tank (T-1) collects waste flow from the three electrode flush lines before discharging to the waste drain.

13. Sampling Point Valve (PV-2) is used to control the waste drained from the waste holdup tank.

14. Ball Valve (BV-2) is used to control the waste drained from the waste holdup tank.

15. Check Valves (CV-2) in the product flush line stops backflow of raw water into the product flush line.

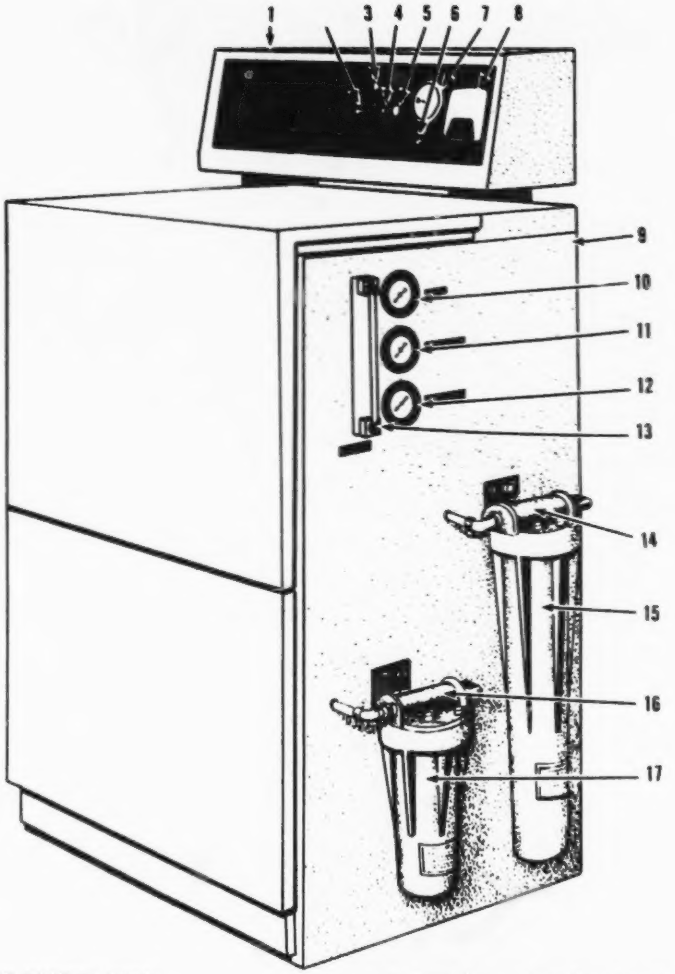
16. Check figures 5-5 and 5-6 for an actual view of the components of the demineralizing unit.



CNG-11R

1. MEMBRANE STACK LIFTING HANDLES
2. PVC END BLOCK
3. STEEL END PLATE
4. MEMBRANES
5. HYDRAULIC CONNECTION
6. MEMBRANE STACK COMPRESSION TIE ROD
7. SOLENOID VALVES SOV2 AND SOV3
8. RECTIFIER AMMETER
9. MULTI-CONTACT POWER CONNECTOR AND CABLE
10. PRESSURE SWITCH PSIA
11. HYDRAULIC TUBING

Figure 5-5. Interior-Electrodialysis



1 RECTIFIER CONTROL PANEL
2 POWER ON-OFF SWITCH
3 RECTIFIER FUSE
4 RECTIFIER ON LAMP
5 POWER SUPPLY RESET PUSHBUTTON
6 POWER ON LAMP
7 OPERATING HOUR METER
8 RECTIFIER AMMETER
9 DEMINERALIZER CABINET
10 FEEDWATER PRESSURE INDICATOR P11 (FILTER CF1)
11 INTER-FILTER (CF1 AND CF2) PRESSURE P12
12 AFTER-FILTER (CF2) PRESSURE INDICATOR P13
13 EFFLUENT FLOW METER
14 FILTER CL1 HEAD ASSEMBLY
15 FILTER CF1 HOUSING
16 FILTER CF2 HEAD ASSEMBLY
17 FILTER CF2 HOUSING
18 PRESSURE REGULATING VALVE PCV1
PRESSURE INDICATOR P14 (INSIDE CABINET)

Figure 5-6. Demineralizing Unit

ELECTRICAL COMPONENTS. The following are the electrical components and their functions for the E. D. system. See foldout 2 (at the end of this study guide) for location of components in the system.

1. Power Supply. AC input provides electrical power for control of system operation. DC output provides power to the membrane stack.
2. On-Off Switch (S1). This switch, when on, supplies AC power to the system--the "power on" light will be lit.
3. Automatic remote control switch (a flat switch in the product storage tank) starts and stops the unit (timer motor).
4. Timer motor (TM1) controls the auomatic operation of the unit. The timer operates the following contacts: TM1-1, TM1-2, TM1-3, TM1-4, TM1-5, TM1-6 and TM1-7.
5. TM1-1 is actuated for approximately ten seconds every fifteen minutes to energize the rectifier (DC output) and open SOV-1.
6. Pressure Switch (PS-1). If feedwater pressure is available (45 psi min), PS-1 will close and bypass TM1-1 for as long as feed pressure is up. The PS-1 switch will energize relay coil K3, Timer Motor (TM2) and the rectifier indicating light. It will also supply power to one side of TM1 contacts; TM1-3, TM1-4 and TM1-5; and to the alarm system.
7. TM1-4 and TM1-5 contacts operate every fifteen minutes--one opened and the other closed--thereby changing the position of SOV-3 and SOV-4.
8. TM1-3 contact operates (at the same time TM1-4 and TM1-5) to open for fifteen minutes and close for fifteen minutes, thereby energizing and deenergizing relay coil K1.
9. Relay K1 is operated to reverse the polarity of the DC power applied to the membrane stack.
10. Timer Motor (TM2) operates, when PS-1 is closed, to record operation time.
11. Relay coil K3 is energized when PS-1 is closed to start the post chlorinator.
12. Ammeter (MR1) shows the total current drawn by the rectifier and sounds an alarm when amperage drops.
13. Relay K2 is energized through TM1-2 when the float switch stops the unit operation (high level in storage tank). K2 contacts energize SOV-2 through TM1-6 and start motor TM1. At this time, the unit will flush with product water for approximately three minutes. TM1 will continue to operate until TM1-2 opens, thereby deenergizing relay 2 and stopping TM1.
14. The unit will be ready to restart on subsequent call for product water when the water level in storage tank falls.

Operation

To get the E. D. unit ready for automatic operation, open the plug valves on the raw feedwater and product flush water lines. Connect the unit to a 110 volt outlet and put the switch S-1 on the console in the ON position. The unit will now operate automatically in response to a signal from the level controller in the product water storage tank. It will keep the level of water in the storage tank between 36 and 52 inches.

The water level controller (float switch) in the storage tank will close when the water level drops to 36 inches. Closing of the float switch actuates the timer motor. The timer motor will actuate the rectifier and supply solenoid valve. However, if the timer was between cycles at the time of the unit's previous shutdown, the rectifier and solenoid valve will not be energized. The time lapse before the rectifier and solenoid valve will be energized can be up to 15 minutes.

At the end of the elapsed time, the timer motor will energize the rectifier and solenoid valve for approximately 12 seconds every 15 minutes. This sequence will continue until adequate feedwater pressure is available to close the pressure switch. When the feedwater pressure is adequate, the rectifier and solenoid valve will stay energized by power from the pressure switch; thereby enabling the unit to produce demineralized water until the water level in the storage tank reaches a high level of 51 inches. The float switch opens at this high level to deenergize the unit and return it to standby condition until there is a call for more demineralized water.

During normal operation, the raw water supply, containing dissolved minerals, flows through filters to remove suspended matter and chlorine from the water prior to entering the membrane stack. The pressure regulating vlave keeps the influent water pressure at the membrane stack. The water is channeled through the membrane stack in two parallel streams. The stream losing ions (impurities) is the product stream, and the stream gaining ions (impurities) is the waste stream.

At the anode electrode, a reaction takes place to produce chlorine gas and at the cathode, hydrogen is produced. The waste water stream is always routed through the electrical compartments for flushing, to keep scale from forming.

The polarity of the membrane stack is reversed every 15 minutes, and at the same time, the solenoid valves change position to change the direction of the effluent waters. During the reversal sequence, there is time delay in switching from the waste water line to product water line. This prevents a "slug" of high TDS water from reaching the effluent storage tank. The quantity of product and waste water is approximately equal.

The E.D. unit is equipped with an alarm circuit. Whenever the E.D. unit operating amperage drops too low, the alarm circuit will energize.

While the E.D. unit is in service,raw water samples are collected daily and tested for iron and chlorine. Product water is tested for TDS and chlorine.

Design Specification

Production:	500 GPD
Waste:	600 GPD
Product Quality:	500 PPM TDS Maximum
Maximum TDS Removal:	Up to 6,000 TDS
Maximum Feed Water Temperature:	100° F
Feed Water Temperature:	50° F
Stack Inlet Pressure:	45 PSI

Instructions

Using the instructions below, operate the electrodialysis demineralization unit.

SAFETY PRECAUTIONS

1. Initially, and each time the unit is moved or dismantled, check the ground connections before turning on DC power. The skid frame should be grounded to the building ground.
2. Do not touch wet stack sides or electrode tabs when the DC power is on.
3. Always wear rubber gloves when voltage probing the membrane stack.
4. Never apply DC voltage to the membrane stack when there is no water flow through the stack.

5. It is normal for the DC amperes to DROP when the feedwater temperature DROPS. NEVER increase DC stack voltage as feedwater temperature drops in an attempt to raise amperage to that recorded at the higher temperature UNLESS you have received specific instructions to do so from Ionics.

6. It is normal for the DC amperage to RISE when the feedwater temperature RISES. If the temperature rises less than 10°F, it is not necessary to lower the DC voltage when this happens. If the feedwater temperature RISES more than 10°F, the DC voltage should be lowered until the DC amperage returns to normal UNLESS you have received specific instructions from Ionics to the contrary.

7. Never allow oil, organic solutions, solvents, detergents, sewage, nitric acid, bleach or other strong oxidizing agents to come in contact with the membranes and spacers unless directed by an Ionics Representative. Membranes can be DAMAGED if operated on a feedwater containing even 0.1 ppm free chlorine.

8. ALWAYS keep membranes wet.

9. When washing down the area, never direct a hose on the membrane stack when the DC power is on.

10. Feedwater containing Calgon or other hexametaphosphates will cause high membrane stack resistance. Avoid operation when these are present.

DESCRIPTION OF UNIT

This Aquamite unit uses an electrodialysis process to demineralize water. It was designed to produce demineralized water without the necessity of constant addition of acid to the brine and electrode streams. The long-term buildup of precipitated salts is prevented by periodic reversal of the electrical and hydraulic "orientation" of the stack. Automatically operated valves switch the main feed flow so that "dilute" water is passed through the manifolds and spacers that formerly conducted brine water, and vice versa. The electrode polarity is automatically reversed: cathodes become anodes and anodes become cathodes.

In this way, no part of the Aquamite unit is exposed to high concentration of brine or caustic electrode solutions for more than 15 minutes at a time.

The Aquamite unit consists of demineralizing membrane stack (or stacks) and power supply (elements basic to all electrodialysis units) and all the valves, operators, switches, sensors, and circuitry required to carry out the periodic cycle reversal automatically and efficiently.

Specific components of this Aquamite unit are described in the following pages.

The system consists of the following components:

1.	S-1	Membrane Stack for water desalination.
2.	POWER SUPPLY	Rectifier portion provides DC power to the membrane stack. Control portion includes provisions for: 1) Starting and stopping the unit by an external signal (supplied by others). 2) Starting and stopping a post chlorinator whenever the unit is operating. (Optional) 3) Sounding an alarm (supplied by others) when the stack amperage falls below a certain limit.
3.	CF-1, CF-2	Cartridge filters remove foreign material (CF-1) and chlorine (CF-2) if present from water prior to membrane stack.
4.	PG-1, PG-2 PG-3	Pressure gauges indicate pressure drop across the filters.
5.	PG-4	Pressure gauge - indicates stack inlet pressure.

6.	PRV-1	Pressure Reducing Valve maintains set pressures at membrane stack to compensate for fluctuations in line pressure and pressure drop across filters.
7.	SOV-1	Solenoid valve shuts off water supply to unit when unit stops automatically (storage full) or manually.
8.	PS-1	Pressure switch de-energizes rectifier, closes SOV-1, and shuts down unit on low feed water pressure.
9.	SOV-2	Solenoid Valve - opens fresh water supply to unit for a preset period of time whenever unit stops automatically (high storage). The purpose is to flush and purge the system of high concentration and gases before a prolonged shutdown.
10.	SOV-3, SOV-4	Solenoid valves for stream switching in sympathy with polarity reversal.
11.	FL-1	Product water rotameter indicates desalted water flow rate in GPM.
12.	T-1	Waste hold-up tank which collects waste flows from the three electrode flush lines before discharging them to waste.

OPERATION OF THE E.D. UNIT

Operating Procedures

Use the instructions below to operate the E.D. unit.

Preoperational Procedures

1. Observe safety precautions.
2. Inspect the unit for any signs of damage or unsafe conditions.
3. Check to see that the unit is connected to a 110-volt outlet and the switch on the console is in the OFF position.

Operational Procedures

NOTE: Observe safety precautions and follow the instructions below:

1. Open the 1/2" plug valves on the raw and product flush line. This hydraulically connects the ED unit to the raw water supply and to the product flush line.
2. Turn both switches on the console to the ON position. This supplies the power to the unit. The power on light will be lit. Allow 15 minutes for the unit to start producing water.
3. Fill out the attached log sheet during this performance.
4. If the start contact of the product tank level control (supplied by customer) indicates a call for water, timer TM1 will start running. This timer will actuate TM1-1 contact for approxiamtely 10 seconds every 15 minutes. Actuation of TM1-1 would energize Feed SOV-1 to open. If feed pressure is available (45 PSI minimum) PS-1 contact will close and therefore by-pass TM1-1 contact for as long as feed pressure is substained. Actuation of either TM1-1 or PS-1 would also energize the rectifier and its red light would come on indicating the unit is producing fresh water.
5. The ammeter on the top console will indicate the total current drawn by the rectifier. The Ionics Field Engineer will establish the proper operating conditions based on water composition, water temperature, unit output, and product water quality desired. These conditions should not be altered without prior communication with Ionics, Incorporated.

The first stage stack voltage is adjusted by changing the transformer tap positions. The tranformer is wired to have coarse taps of 30 volts and fine taps of 5 volts. By proper connection of the coarse and fine taps, any voltage from 0-120 volts could be obtained in 5 volts increments. The second hydraulic stage voltage is varied by changing the adjustable resistors R2.4. NEVER ATTEMPT TO CHANGE THE VOLTAGE WHEN POWER IS ON TO THE UNIT.

Every 15 minutes the time TM1-3 reverses the polarity of the DC power applied to the stack. At the same instant the 3-way solenoid valves (SOV-3, SOV-4) in the stack outlet piping hydraulically reverses the stack connections in sympathy with the polarity reversal so that the product and waste streams can continue to flow to the product storage tank or waste disposal system as the case may be.

At each reversal sequence, the valve (SOV-3 or 4) connected to the stream changing from waste to product will have its reversal action delayed by an adjustable period of time to maintain its stream diverted to waste until its salinity drops to acceptable limits. A feed pressure of 45 PSI has been assumed and the unit has been factory adjusted to allow a delay of forty-five seconds. But, because of varying feed water pressure, minor adjustments may be necessary upon installation.

On a high product level signal, control is transferred from TB1-13 to TB1-12 de-energizing the rectifier and SOV-1, therefore shutting off the raw water supply. Simultaneously relay K2 energizes since TM1-2 contact would be closed. K2-1 contact would close energizing SOV-2 which will open the product flush lines for as long as TM1-6 is set at (adjustable from 1-5 minutes). TM1-6 is factory adjusted to 3 minutes which will give adequate water flushing for a product flush line pressure of 15 PSI. TM1 will continue to operate until TM-2 opens, therefore de-energizing Relay K2 and stopping TM1. The unit will be ready to restart on a subsequent call for water when the product level falls.

0. Take a TDS of both the raw and product water.

1. No further attention is required except for routine maintenance.

LOG SHEET FOR E.D. OPERATION

DATE/TIME								
FEEDWATER TEMP °F								
PRODUCTION FLOW RATE								
CURRENT (AMPERES)								
PRESSURES	BEFORE FILTERS							
	AFTER FILTERS							
STACK PROBE RESULTS								
HOURS OPERATION								
SINCE LAST LOG								

REMARKS: Votages ______________

TDS Reading ______________ Raw

______________ Product

EXERCISE III-5a

PART 1

INSTRUCTIONS

Complete the following questions. Consult the instructor if you have any questions.

1. Electrodialysis uses an electric current applied acrosss a/an ____________ using a D.C. potential.

2. The production capacity of the E.D. unit is ____________ gal/day.

3. The cations will flow toward the ______________, and anion will flow toward the ________________.

4. The unit will waste ________________ gal/day.

5. Maximum feed water temperature is ____________°F.

6. The __________ filter removes turbidity and the _____________filter removes chlorine.

7. The stream of deionized water is called ________________water.

8. Every ____________ minutes the polarity of the power applied to the stack is reversed.

9. A cation membrane will only permit _________________ to pass through.

10. An anion membrane will only permit _________________ to pass through.

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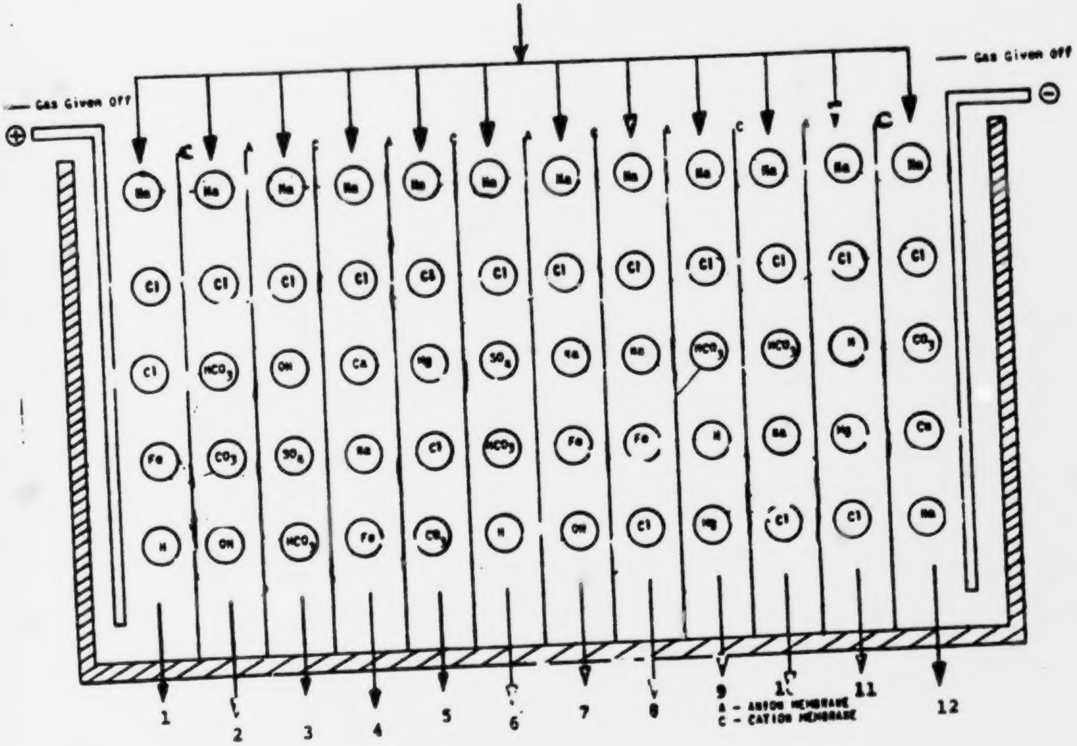
Gas Given off
Gas Given off
⊕
⊖
C
C
A - ANION MEMBRANE
C - CATION MEMBRANE

Figure 5-7

PART 2

INSTRUCTIONS

1. In figure 5-7, using a pencil, draw a line showing the direction each ion will be moved by the charges on the anode and cathode.

2. If the ion passes through the membrane, draw the line across the membrane.

3. Where the membrane stops the ion, draw a small circle at the end of the line.

4. Fill in the blanks at the bottom of figure 5-7, identifying the streams as follows:

   D - Dilute stream
   C - Concentrate stream
   Cath - Cathode stream
   An - Anode stream

5. Show the pH change and the gas formed in the electrode streams, at the upper left and right portions of the diagram.

PART 3

APPLICATION PRINCIPLES OF OPERATION AND COMPONENTS OF ELECTRODIALYSIS UNIT

PART 4

INSTRUCTIONS: Match the terms in Column B with statements in Column A. Terms may be used once, more than once, or not at all.

	COLUMN A. STATEMENTS	COLUMN B. TERMS
_____	1. Demineralizes water	a. E.D. Unit
_____	2. Maximum product water quality	b. 3
_____	3. Maximum TDS removal	c. Membrane
_____	4. Length of each cycle	d. 2 minutes
_____	5. Wastewater gallons per day	e. 600 gal
_____	6. Used at missile sites	f. 45 psi
_____	7. Removes chlorine	g. 100°C
_____	8. DC current must pass through this component	h. 6000 ppm
_____	9. Minimum pressure across stack	i. 500 gal
_____	10. Maximum amount product water	j. 600 ppm
_____	11. Number cycles	k. 15 minutes
_____	12. Selective to certain ions	l. 100°F
_____	13. Maximum temperature unit will take	m. Cartridge filter 2
		n. 2
		o. Cartridge filter 1
		p. Stack
		q. 500 ppm

INFORMATION

MAINTENANCE OF ELECTRODIALYSIS DEMINERALIZER

The electrodialysis unit is used at some SAC Minute Man II and III missile sites, to produce potable water for the missile maintenance, security, and capsule crews. When working on these units you should use the manufacturer's manual for the proper maintenance.

TROUBLESHOOTING AND MAINTENANCE

Maintenance

The only routine maintenance required is to change the filters when their respective pressure drops reach 10 psi.

Stack disassembly for inspection would be required when high voltage probe indicates salt deposit and when excessive pressure drop indicates slime deposit. If slime or deposits are noted, clean membrane with a cloth or soft bristle brush and reassemble.

1. High Probe (check for salt deposits)
2. Excessive Pressure Drops (check for slime deposits)

Troubleshooting

If the E.D. unit does not function properly, the reason could be something as simple as a loose wire or plugged filter or it could be more serious as a membrane stack problem.

The following troubleshooting list should be followed and new items should be added as they are discovered.

1. For any trouble, take a complete set of reading from the operating log sheet and check those items which are not normal.

2. If the product salinity is high by taste and analysis and the DC amperage is normal or higher than normal, follow the following procedures.

    a. Check the flow rate on the product stream rotameter for higher than normal rate of flow.

    b. If the rate of flow is normal, analyze the feedwater for higher than usual salinity.

    c. If feedwater salinity is higher than usual, disassemble the stack and look for ruptured membrane.

3. If the product salinity is high and the DC amperage is below normal:

    a. Check for low feedwater temperature.

    b. If temperature is normal, probe the stack.

4. If product flow is lower than normal:

    a. Check for plugged valves and filters.

    b. Check for sliming, scaling and proper alignment of the stack.

Following the instructions below, perform the necessary test:

Test for Salinity (TDS)

1. Fill container 1/2 full of sample of product water.

2. Select low range probe.

3. Rinse the probe in cylinder of sample.

4. Plug in meter and turn switch to "ON" position.

5. Check temperature of sample.

6. Set temperature control on meter to temperature obtained in Step 5.

7. Jiggle the probes in sample until all of the air bubbles escape through the vent holes. Keep probes submerged below vent hole level.

8. Turn the conductivity scale knob until the dark area of the eye or null indicator is at its widest size.

9. Read the meter and record the microhms specific conductivity of sample.

10. Turn switch to "OFF" position and unplug the meter.

11. Rinse the probes in distilled water and store.

12. Use the conversion chart furnished with the meter to convert specific conductance to ppm NaCl equivalent. (The E. D. should be producing water with a maximum of 500 ppm TDS.)

THE MEMBRANE STACK

1. DESCRIPTION

The membrane "stack" is so called because it is composed of a large number of stacked pieces, like a deck of cards. Half of these pieces are spaces and half are membranes, and the spaces and membranes alternate from the bottom to the top of the stack. In other words, if one examines any portion of the stack, he finds a membrane above and below every spacer (except at the electrodes) and a spacer above and below every membrane. Two membranes or two spacers should never occur together.

The Aquamite membrane stack contains six hydraulic stages internally connected in series and with a total of 100 cell pairs. A cell pair is composed of one anion membrane, one cation membrane and two intermembrane spacers is a complete, basic demineralizing element. Metal electrodes which apply the direct current electric power required for demineralization are placed in the center and at the ends of the stack. The arrangement is such that these hydraulic stages occur within each electric stage.

A. The Membranes

The two types of membranes used are called anion membranes and cation membranes. They look like woven cloth that has been plastic coated. Each membrane is identified by printing near one edge. Anion membranes are labelled "Anion" in red ink, whereas cation membranes are labelled "Cation" in green ink. In general, the color of the anion membrane itself is amber and the color of the cation membrane is pale green. Note that each membrane has holes which are called manifold holes. When the stack components are aligned and compressed between the steel end plates, the manifold holes form the flow channels for the dilute and concentrate streams.

B. Spacers

The intermembrane spacers are molded plastic sheets which also contain manifold holes. Only two of these are connected to the serpentine flow path in the spacer. Each spacer is identical but differs in its orientation in the stack. The spacers in every other cell pair are connected to the same manifold holes. Careful attention to this point is essential for proper stack operation. The techniques of stack assembly and disassembly are fully decribed in the following sections.

C. Stack Specifications

Number of cell pairs:	Stage 1	20
	Stage 2	17
	Stage 3	13
	Stage 4	20
	Stage 5	17
	Stage 6	13

Number and type of anion membranes: 100 111BZL-183

Number and type of cation membranes (4 oz): 94 61AZL-183

Number and type of heavy cation membranes: 8 61AZL-065

Number and type of spacers: 200 molded 9" x 10"

Number of special electrode spacers: 4

Electrodes: 4 expanded, platinized
Columbium

During troubleshooting it is sometimes necessary to probe the membrane stack. Use the following directions to probe the Electrodialysis Unit stack.

INSTRUCTIONS

Following the instructions below, perform the necessary maintenance.

Electro-Membrane Stack Probing

1. Precautions

   a. Because the probing operation must be done while the stack is electrically hot, the following precautions should be observed:

      (1) Always wear rubber gloves.

      (2) Never touch the side of the stack directly.

2. Procedure

   a. If the stack side is not completely wet, loosen the compression nuts slightly to increase the leak rate.

   b. If the side of the stack is very dry and encrusted with salt, wet down only when the DC power to the stack is off.

   c. Turn DC power on.

   d. Locate the triplet voltmeter and set the selection dial at a DC volt range higher than the voltage on the stack.

   e. With the probes spread apart a slight distance, press them firmly against the side of the stack. If the reading is in the proper direction, the polarity is correct, if the reading is in the wrong direction, off scale, simply reverse the leads. This will give the proper polarity position.

   f. With the probe leads in the proper position across the first and third stage electrodes, read the DC voltage. This should be approximately the same as the rectifier DC output voltage.

   g. Next, turn the selector dial to the 0-50 range and measure the voltage across the individual electrodes. This can be done by placing one probe on the electrode and the other probe slightly below the electrode. This reading should be in the 1-10 volt range. Anything abnormally higher than this would indicate a faulty electrode.

h. Repeat this procedure for the fourth, fifth, and sixth stages and associated electrodes.

i. Place the probes approximately 2" apart and take readings down the side of the stack maintaining this constant distance between the probes. If the stack is in normal condition, the voltage drop readings will be approximately equal. Variances ± 1 or 2 volts should be ignored. If any section shows a radically high reading, it indicates some abnormality in the operation of that particular section. Mark the side of the stack with a red crayon so that this spot can be inspected closely on disassembly.

NOTE: Because of the different flow characteristics of each stage, the different stages will indicate slightly different voltage radients (volts per inch). The decisive criterion of malfunction would be that the voltage gradient at a point of any stage being different at some other point of the same stage by more than 2-3 volts.

INSTRUCTIONS

Using the following directions, disassemble and reassemble the membrane stack.

Electro-Membrane disassembly/reassembly

DISASSEMBLY PROCEDURE

1. Remove the stack from the container and place on end in a nearby convenient working location.

2. Loosen the top compression nuts evenly until they are finger loose, then remove the nuts. The tie rods will remain in place.

3. Remove the top steel end plate and the top PVC end block.

4. Before beginning the actual membrane and space disassembly, the operator should wash his hands thoroughly to prevent any bacterial contamination of the membranes.

5. Disassembly of the spacers and membranes can now be done either in sections or pairs, depending on the purpose.

   (a) For complete and thorough inspection, the stack should be disassembled in "pairs", that is, one spacer and one membrane together.

   (b) If disassembly is for the purpose of investigating a localized trouble spot, the atack can be removed in sections.

REASSEMBLY PROCEDURE

The reassembly procedure is the reverse of the disassembly procedure. Some precautions which should be observed are listed below.

1. Always alternate anion and cation membranes.

2. Frequently check the alignment of the stack components during assembly to assure that the manifold holes are aligned and that the sides of the stack are straight and true.

3. Do not allow foreign material to enter the stack.

4. Be careful to alternate the spaces so that every other spacer is connected to the same manifold holes. Two adjacent spacers should never be connected to the same manifold holes.

5. After the top end plate is replaced, retighten the compression nuts evenly by gradually tightening them in sequence.

6. Replace stack in container.

SUMMARY

Being able to provide a good supply of pure fresh water is fast becoming one of mankind's major problems. As more and more people are being born, the demand for water increases about three times as fast. There is a lot of salty or brackish water available in different parts of the world, but making it fit for domestic use is a big problem.

There are several ways of making good water out of bad. Most of these ways are too expensive to be used. One way that is both effective and economical is to use the permeable membrane deionizer. This system makes good water out of bad by forcing the bad ions through a membrane and leaving the good water behind. The source of power used to force the bad ions through the membrane is DC potential, which is usually obtained from a rectifier. In this type of unit, there is no direct chemical reaction and no need for regeneration as required by some other units.

The smaller the number of moving parts, the less maintenance is required on a unit. Various pumps are required with this type of unit, the number depending upon the specific design of the installation. These pumps are utilized to maintain water flow through the "stack" as required. Other pumps are required to pump chemicals into the water at different locations provide efficient operation of the unit. It must be remembered that a stack has to be assembled properly or it will fail to function. Specific types of spacers are required adjacent to the electrodes. The anion and cation membranes which pass only ions, not water, must then be alternated with spacers between each that are connected to alternate parts separating the dilute stream from the concentrate or ion gaining stream.

EXERCISE III-5-5b

1. How often is the maintenance performed on the electrodialysis unit? ____________

____

2. When should the cartridge filters changed on the electrodialysis unit? __________

____

3. List the procedures for determining causes of the following problems.

   a. Product salinity high and DC amperage is normal or higher than normal.

      (1) ____

      (2) ____

      (3) ____

   b. Product salinity high and DC amperage is lower than normal.

      (1) ____

      (2) ____

   c. Product flow is low.

      (1) ____

      ____

      ____

      (2) ____

      ____

      ____

FIELD WATER PURIFICATION UNITS

OBJECTIVES

Given a sketch of a proposed water point and site selection criteria, locate and identify the correct site to set up the unit according to TM 5-700. Three of the four must be correct.

Given a diagram and information related to the ERDLATOR, locate and identify components. Ten of the twelve statements must be correct.

Using TO 40W4-9-1 and information related to the operation of the ERDLATOR, match statements pertaining to the operation of the unit. Twelve of the fifteen must be correct.

Using TO 40W4-9-1, complete statements pertaining to preventative maintenance procedures and troubleshooting operational problems of a 600 gph ERDLATOR. Nine of the fifteen statements must be correct.

Given a diagram and information related to the Reverse Osmosis Water Purification Unit (ROWPU), locate and identify the ROWPU components IAW T.O. 40W4-13-1. Seven of the eleven matched components must be correct.

Using T.O. 40W4-13-1 and related information, write the correct procedures used to perform maintenance on the Reverse Osmosis Water Purification Unit. Six of the ten procedures must be correct.

INTRODUCTION

This section of your study guide will provide information for military personnel engaged in field water supply. A field water supply may be used in training exercises, combat zones, occupation areas, and other locations such as disaster stricken areas. This section covers water quality, requirements, development of water points and water purification units. Details on the operation and maintenance of each field unit will be discussed. Three publications will be used to complete this section: TM 5-700 Field Water Supply; TO 40W4-9-1, Field Water Purification Unit 600 gph; and TM 5-4610-215-10, Operator's Manual, Water Purification Unit, Reverse Osmosis 600 gph. Chapters and paragraphs are outlined for your study reference. The soldier's water supply affects the health and general welfare of that person; the combat efficiency and morale. In extreme situations, a soldier's limit without water is 16 hours. To supply good quality water the equipment must be highly efficient and highly mobile.

INFORMATION

PURPOSE OF THE FIELD WATER UNITS

Water that is to be used for field operations must be treated to make sure that it is free of germs, excessive minerals and organic matter. The water must also be cool, clean and free of objectionable taste and odors. Every effort should be made to give the troops water of very high quality. If little or no water is available, it will have a very adverse effect on the troops in the field. With the use of a field water purification unit, water of good quality can be obtained.

Types of Field Water Purification Units

There are several types of field water purification units that are used to make water safe for human consumption and palatable for good taste and appearance. These include the ERDLATOR and the reverse osmosis water purification unit (ROWPU). The types of ERDLATOR units are as follows: 1/4 GPM hand operated unit, 420 GPH skid mounted unit, 600 GPH trailer mounted unit, 1500 GPH van type body mounted unit, 3000 GPH van type body mounted united, 3000 GPH base mounted unit and a 10,000 GPH unit. The ROWPU unit is a 600 gph skid mounted unit.

The 600 GPH trailer mounted ERDLATOR is used by the Air Force today. This will be the unit that will be discussed in detail. It is designed to treat 600 gallons of water per hour or ten gallons a minute. The unit removes both suspended solids and dissolved gases from any fresh water source. It is placed in a special purpose cargo body mounted on a 2 1/2 ton 2-wheel trailer. The unit is made up of an ERDLATOR assembly, diatomite filter, filter pump, chemical feed equipment, pipes, valves, and electrical control. The support equipment includes a three kilowatt gas engine driven generator set, gas engine driven pump, a portable electric driven pump, two 500-gallon water storage tanks, necessary hoses and fittings, water testing equipment, and a supply of chemicals. This unit can be either operated on the trailer or can be removed and operated on flat terrain. Figure 6-3 shows the unit and all of the equipment stored on the trailer. The 600 GPH skid-mounted ROWPU is also used by the Air Force today. This unit will be discussed in this chapter.

The unit is also designed to treat 600 gallons of water per hour. The complete 600 GPH Reverse Osmosis Water Purification Equipment Set is described in this chapter, although some components are separate units from the complete R.O. set such as, the generator set, collapsible water tanks, chemicals and support equipment and supplies. Figure 6-3 shows the unit and all of the equipment stored on the trailer.

WATER REQUIRED TO MEET SPECIFIC NEEDS

Personnel in the field need water which is both potable and palatable for cooking, cleaning, bathing and drinking. To insure that the water is safe for treatment, the selection of the site is important. The procedure that is used in the selection of a site will be covered in the following topics:

- Water Needs, TM 5-700
- Selecting Raw Water Sources, and points; TM 5-700 Chapter 4, Sections 1 and 2.
- Perform Stream Survey

This study guide does not cover all of the information on this subject. A copy of TM5-700 is to be obtained and researched for complete details.

Water Needs

The table below shows how much water is needed for troops in the field under certain conditions.

Daily Water Requirements

1	2	3		4
Unit Consumer	Conditions of use	Gal per unit Consumer per day		Remarks
		Temperate/Cold	Desert/Jungle	
Man-------	In combat:			
	Minimum--------	1/2-1	2-3	For eating and drinking only, periods not to exceed 3 days.
	Normal---------	2	3-4	When field rations are used.
		3	6	Drinking plus small amount for cooking or personal hygiene.
	March or bivouac	2	5	Minimum for all purposes.
	Temporary camp	5		Desirable for all purposes (does include bathing).

Table 6-1. Water Needs

Daily Water Requirements				
1	2	3		4
Unit Consumer	Conditions of use	Gal per unit Consumer per day		Remarks
		Temperate/Cold	Desert/Jungle	
	Temporary camp with bathing facilities	15	---------	Includes allowances for waterborne sewage system.
	Semipermanent camp	30-60	---------	
	Permanent Camp	60-100	---------	
Vehicle---	Level and rolling country	1/8-1/2	---------	Depending on size of vehicle
	Mountainous country	1/4-1	---------	Depending on size of vehicle
Hospital	Drinking and cooking	10 per bed	---------	Minimum; does not include bathing or water for flushing.
	Water for waterborne sewage	50 per bed	---------	Includes water for medical perpersonnel.

Table 6-1. Water Needs (Cont'd)

Selecting Raw Water Sources

A good water source is one that is of sufficient quantity to meet the needs and of such quality that it can be approved for treatment by the field water purification unit. A water source that is for military use is known as a water point. Water sources will fall into two categories, surface and ground water. Surface water includes streams, lakes, rivers and ponds. Ground water includes wells and springs. Surface water sources are very easy to find and use, as compared with ground water sources. Normally, surface water sources are used for water points.

Stream Survey

To choose a water point, a stream or water survey is done. An environmental support specialist and a person from the base surgeon's office is responsible for the selection of a raw water source. When performing a stream survey, make a sketch of the site and any other facts of importance.

Water Points. There are several things that are to be considered during the selection of a water point. These are:

1. QUANTITY OF WATER. Make sure that there is a sufficient amount of water available.

2. QUALITY OF THE WATER. The water must be of such quality that it can be readily purified with the field water purification unit. If kits are available take tests on pH, chlorine demand and presence of chemical agents. If you do not have a kit, make close observations on the following characteristics:

- Color
- Turbidity
- Odor
- Taste (use with caution)
- Possible sources of pollution
- Condition of vegetation around source; dead or mottled vegetation may indicate the presence of chemical agents
- Presence of dead fish, frogs, etc.

3. ROUTES OF COMMUNICATIONS. A good water point must not be hard to get to by vehicles and personnel. First, a good road net with turn around and a good parking area is needed. Second, the water point must have good cover and concealment. The site should be located on a through road that can hold very heavy loads.

4. SITE CONDITIONS. When two or more sites have met the above requirements, the choice of a water point is based on the following site conditions.

a. DRAINAGE. The site must be on high ground that is porous to prevent it from becoming excessively muddy or swampy when it is being used all of the time.

b. SECURITY. The site shall be a safe distance from artillery and aerial targets. The site will be safe against any ground attacks and sabotage of storage facilities.

c. BIVOUAC FOR PERSONNEL. The bivouac area for the water treatment personnel must be close to the unit in case of an emergency, yet far enough from the unit to maintain proper sanitation of the water source. The bivouac area will be downstream from the water source.

Read additional information about water requirements, selecting raw water sources, and stream survey which are found in TM 5-700 starting on page 3, paragraph 3 and 4; paragraphs 8 and 9; paragraphs 25, 26 and 27; and page 141-142, table 1. Also read Development of Water Points, page 41-48, Section II.

Lyster Bags

Lyster bags are used to store and dispense treated water to the troops in the field. Water is transferred to the bag by a water tank on a trailer. The Lyster Bag holds 36 gallons of treated water and is made of canvas. This porous canvas permits the seepage of water and cooling by evaporation. The bag has a cover which fits snugly around the upper part to prevent the contamination of the water by dust and insects. The bags are issued to units on the basis of one per hundred people. These bags should be inspected frequently for cleanliness.

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EXERCISE III-6-6a

PART I

INSTRUCTIONS

Using the information from your study guide and TM 5-700, complete the following statements pertaining to the development of water sources.

1. Development of a water source includes all work which increases the ______________ and improves the ______________ of the water.

2. In developing a source, ______________, ______________, ______________ and other similar improvements may be used to increase the ______________ and ______________ of the water.

3. Water at inlet points should be ______________ and ______________ as possible.

4. For normal field water supply, ______________ ______________ is the most accessible type of water source.

5. When a stream is too shallow to allow sufficient water coverage above the intake strainer, a ______________ should be made, and the screen laid on a ______________ or ______________ for support.

6. The level of water in a stream can be raised to cover the intake screen by making a ______________.

7. A ______________ can be made to support the intake screen and hose.

8. A ______________ can be made to prevent or reduce the mud and silt, improving the quality of water intake.

9. In desert regions water may be found in ______________.

INFORMATION

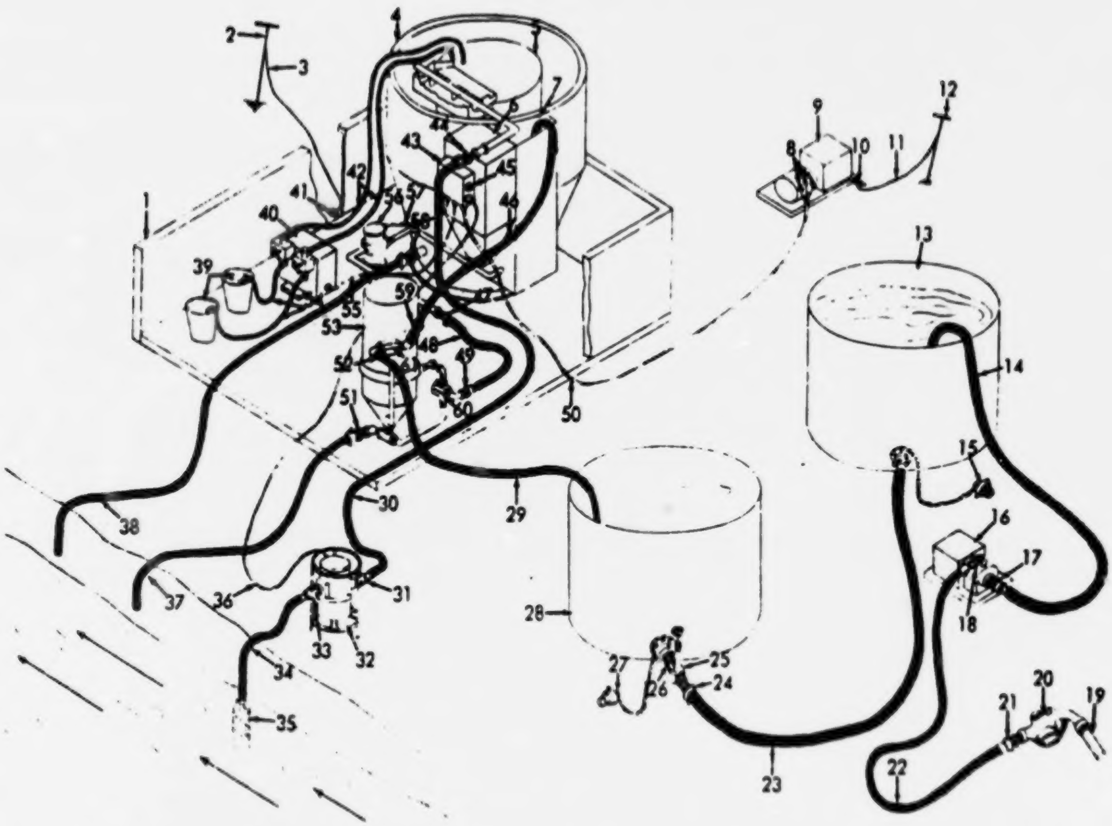
PRINCIPLES OF OPERATION OF THE ERDLATOR

The 600 GPH (gallons per hour) field water purification unit (figure 6-2) and accessories are assembled in a special purpose cargo body mounted on a 2-1/2 ton, 2-wheel trailer chassis. The cargo body is specially designed to carry all of the major components, consisting of an ERDLATOR assembly; a filter section with one filter; a gasoline engine-driven, 3-kilowatt generator; chemical feed equipment; raw water pump; distribution pump; electrical control box; and the necessary hose assemblies and chemicals.

This unit has two five hundred gallon collapsible tanks that are used to store the good water. This unit is designed to be used by troops in the field. It is small and can be carried by most aircraft. The four basic steps that are used to make good water out of bad water are coagulation, sedimentation, filtration, and disinfection. The main chemical is put in water, it joins with the alkalinity in the water to form a substance known as floc. When first formed, the floc is very small and looks like fog in the water. After mixing the floc, it forms into a clump and traps the fine particles in the water. This causes them to drop or settle out. If the water does not have enough alkalinity it is necessary to add some limestone to the raw water. The addition of limestone aids in minimizing floc carry-over to the filter by "weighing" the floc produced in the sludge blanket zone of the field water treatment unit.

Plain sedimentation is not ordinarily used in field water treatment because the long period required for complete settling would call for an impractical number of settling tanks. However, in emergency situations, such as taking water from a swift-flowing stream which is heavily silt laden, special sedimentation tanks may be set up as a first step. This initial removal of turbidity reduces the load on the coagulation and filtration steps of the water treatment process and the frequency of filter backwashing is reduced. Filtration consists of passing the water through some porous material to remove the suspended impurities. Filtration is one of the oldest and simplest procedures known to man for removing suspended matter from water and other fluids. The most effective and portable filtration system in existence is the diatomite filter unit. In the diatomite/filter, water is passed through a layer of diatomaceous silica, also called diatomaceous earth, which consists of skeletal remains of minute algae (diatoms) found in marine deposits that have lifted above sea level.

The diatomite type filter accomplishes highly efficient filtration. Properly operated diatomite filters are capable of removing from coagulated and settled water, amoebic cysts, the cercariae of schistosomes, and approxiamtely 90 percent of the bacteria, as well as producing water with less than one unit of turbidity. Whenever working with the field water purification unit, follow the safety rules in TO 40W4-9-1.



1 Cargo body
2 Cargo body ground rod
3 Ground cable
4 Erdlator tank
5 Downcomer
6 Sludge concentrator tank
7 Wet well
8 Generator terminal lugs
9 Generator set
10 Generator ground lug
11 Generator ground cable
12 Generator ground rod
13 Second filtered water storage tank
14 Distribution pump suction hose, rubber, 1-1/2 in. x 10 ft.
15 Filtered water tank chain and cap, 1-1/2 in. male hose
16 Distribution pump (gasoline driven)
17 Adapter, male pipe to female hose, 1-1/2 in.
18 Adapter, male pipe, 1-1/2 in.
19 Distribution nozzle extension pipe, 1-1/2 in.
20 Distribution nozzle, 1-1/2 in. pipe thds
21 Adapter, male, pipe to female hose, 1-1/2 in. x 25 ft.
221 Distribution hose, fabric, 1-1/2 in x 25 ft
23 Hose, rubber, 1-1/2 in. x 10 ft
24 Adapter, male pipe to hose, 1-1/2 in.
25 Valve, gate, 1-1/2 in. female pipe
26 Adapter, male, pipe to hose, 1-1/2 in.
27 Cap and chain male pipe, 1-1/2 in.
28 First filtered water storage tank
29 Filtered water hose, 1 in. x 25 ft
30 Raw water pump discharge hose, fabric, 1 in. x 25 ft
31 Adapter, male pipe to female hose, 1 in.
32 Raw water pump
33 Adater, male pipe to female hose, 1 in.
34 Raw water pump suction hose, rubber, 1 in. x 10 ft
35 Strainer, raw water pump suction, 1 in. female
36 Raw water pump electric cable
37 Filter waste water hose, rubber, 1-1/4 in. x 10 ft
38 Erdlator tank waste water hose, rubber, 1-1/4 in. x 10 ft
39 Rubber pails
40 Chemical solution feeder
41 Cargo body ground lug
42 Chemical solution feeder discharge plastic tubing, 3/4 in. od x 68 in. (2 ea)
43 Electrical control box
44 Adapter, male, pipe to male hose, 1 in.
45 120 volt outlet receptacle
46 Recirculating hose, rubber, 1 in. x 10 ft
47 Adapter, male pipe to hose, 1 in.
48 Hose, rubber 1 in. x 10 ft
49 Adapter, male pipe to female hose, 1 in.
50 Main power cable
51 Adapter, male pipe to hose, 1-1/4 in.
52 Adapter, male pipe to male hose, 1 in.
53 Diatomite filter
54 Chemical solution feeder suction tubing, 3/4 in. od x 48 in.
55 Chemical solution feeder power cable
56 Filter pump
57 Filter pump power cable
58 Adapter, male pipe to male hose, 1-1/4 in.
59 Adater, male pipe to male hose, 1 in.
60 Influent plug valve, 1 in.
61 Effluent plug valve, 1 in.

Figure 6-1. ERDLATOR Assembly

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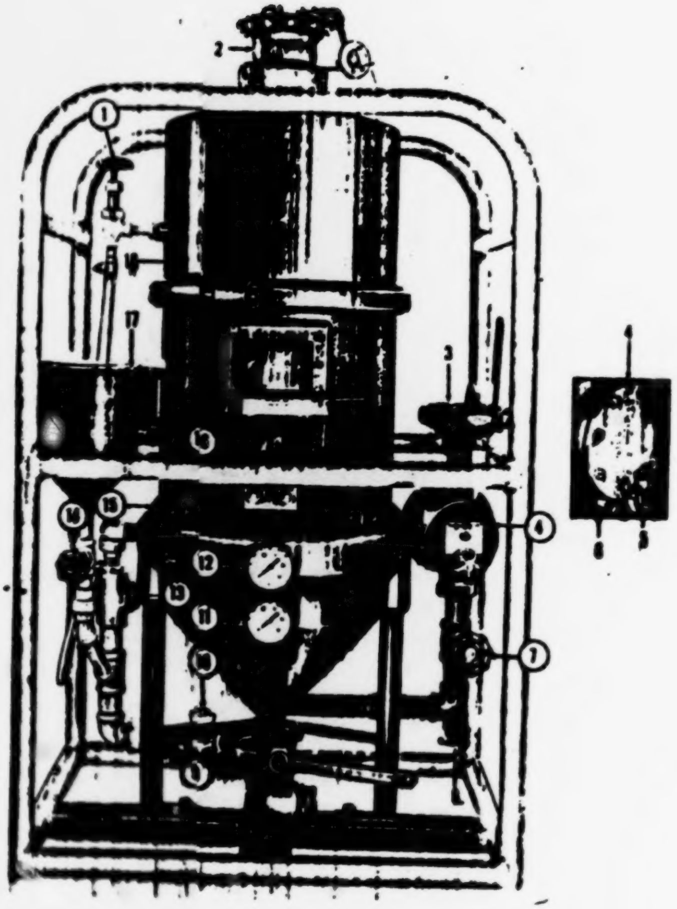
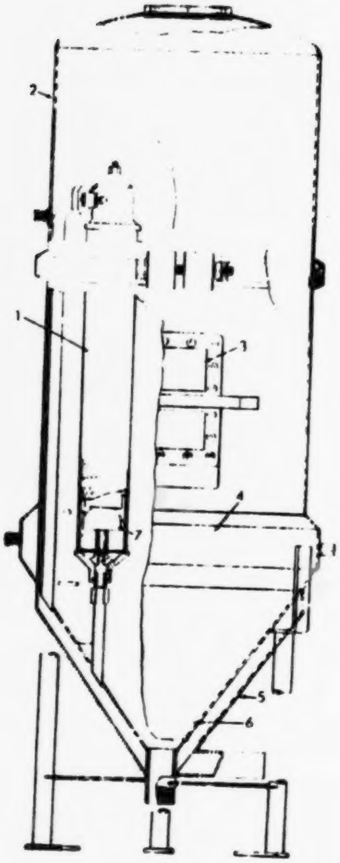


1 Valve CV 11, angle globe, 1-1/2 in.
2 Valve ARV 17, air release
3 Valve CV 23, filter effluent 3-way plug, 2-port, 90° turn, 1 in.
4 Valve CV 20, flow controller, 1 in.
5 Draincock, DC 22, 1/4 in.
6 Draincock DC 21, 1/4 in.
7 Valve CV 18, gate, 1 in.
8 Draincock DC 19, 1/2 in.
9 Valve DV 16, quick acting, 1-1/4 in.

10 Valve SCV 27, swing check, 1 in.
11 Gage PG 3, effluent pressure
12 Gage PG 2, influent pressure
13 Valve CV 13, filter effluent plug, 3-way, 2 port, 1 in.
14 Valve CV 15, gate, 1/2 in.
15 Wash ring
16 Filter window
17 Filter precoat funnel
18 Diatomite filter housing cover



1 Filter element (4 rqr)
2 Filter housing cover
3 Filter window
4 Wash ring
5 Influent section
6 Effluent section
7 Plastic cup (32 rqr)

Figure 6-2. D.E. Filter Unit

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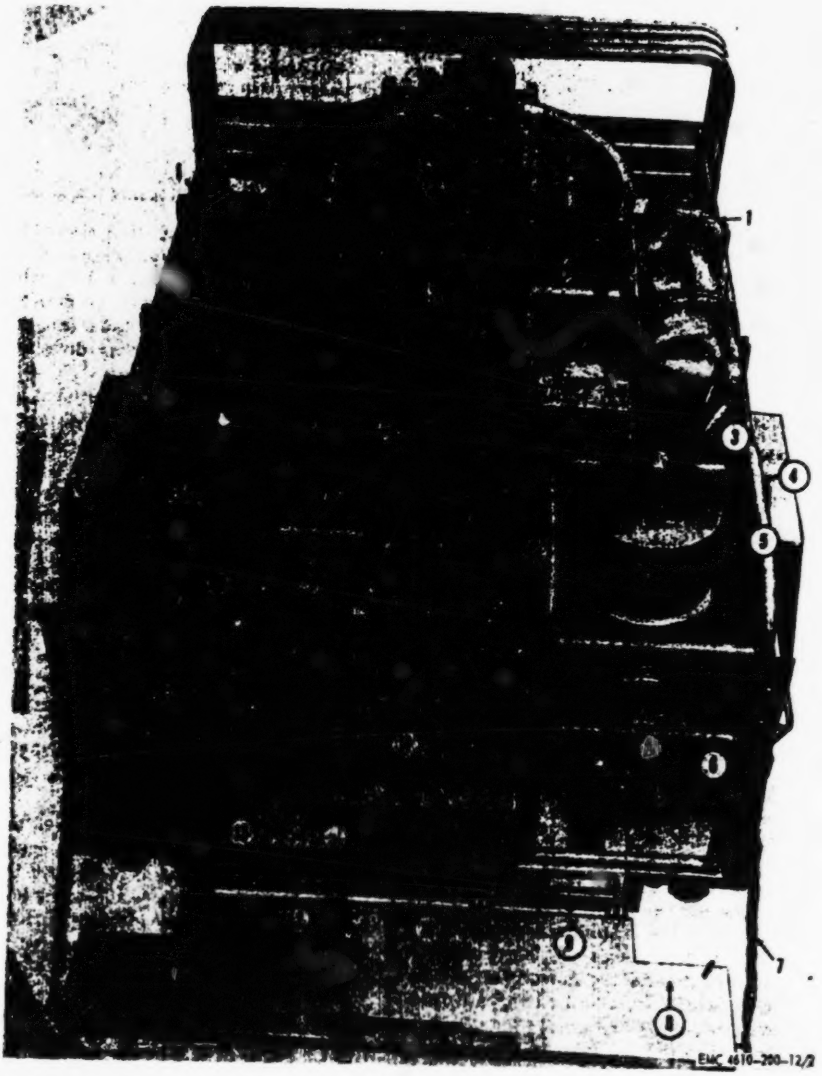

1 Collapsible fabric tank, 500 gal (2 rqr)
2 Roof bows
3 Air release valve
4 Filter tubular frame
5 Filter
6 Flow controller valve
7 Trailer tailgate chain
8 Trailer tailgate
9 Tool box
10 Chemical box
11 Distribution pump
12 Accessory box
13 Generator
14 Trailer body rack
15 Tank staves
16 Raw water pump with canvas cover
17 Pad tiedown strap and metal cover
18 Rubber pails
19 Filter pump

Figure 6-3. 600 GPH Field Water Purification Unit on a 2-1/2 Ton Trailer

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Components and Their Purpose

The 600 GPH field water purification unit is made up of the following components:

ERDLATOR TANK. This tank is a circular funnel-shaped unit which is of one piece aluminum construction. This tank has a capacity of 245 gallons.

AGITATOR DRIVE MOTOR. It is an electric motor used to drive both the agitator drive shaft and slurry air pump.

SPEED REDUCER. It reduces the speed from the agitator drive motor to the drive shaft.

AIR PUMP. It is used to furnish air to both of the chemical slurry feeders.

BRIDGE RAIL. Two aluminum rails are attached to the top of th Erdlator tank; these rails are used to support the drive motor, speed reducer, and air pump.

INFLUENT FLOW CONTROLLER. When raw water first enters the unit, it passes through the influent flow controller. It is an orifice designed to allow only ten gallons of water per minute to pass through.

ASPIRATORS. These spray nozzles remove any dissolve gases that may be present in the raw water.

INFLUENT LAUNDER. It collects the water after passing through the aspirators. It allows this water to overflow into the downcomer tube.

DOWNCOMER TUBE. Also known as the mixing zone. It is a tube located in the center of the erdlator tank. This tube allows the mixing of raw water with chemicals.

AGITATOR SHAFT AND DISCS. It consists of a shaft with four circular discs. These discs mix the chemicals and water in a clockwise rotation.

BEARING SUPPORT. This bearing is water lubricated and is at the bottom of the agitator shaft.

BAFFLES AND BAFFLE RING. It is a ring near the bottom that is attached to the erdlator tank with a series of short baffles which support the downcomer tube. These short baffles deflect or reverse the flow of water.

SLUDGE BLANKET ZONE. It is located in the lower section of the erdlator tank. This zone contains all of the floc that has settled out.

CLEAR WATER ZONE. It is located in the upper section of the erdlator tank. It contains the clear or coagulated water.

EFFLUENT LAUNDER. It is a continuous trough which collects the clear or coagulated water in the clear water zone.

WET WELL TANK. This tank provides for the limited storage of coagulated water and serves as a sump for the suction of the filter pump.

WEIR BOX. Inside the weir box a draw off port allows excess slurry to flow into the weir box which takes this slurry or sludge to the sludge concentrator tank.

SLUDGE CONCENTRATOR TANK. This tank acts as an auxiliary clarifier which provides some additional clear water to the wet well tank.

SLURRY FEEDER. This unit has two compartments that are the same. One compartment supplies limestone and activated carbon to the downcomer tube and the other one supplies diatomite to the suction inlet of the filter pump.

SOLUTION FEEDER. It is made up of two diaphragm pumps operated by one electric motor. This pumps ferric chloride and calcium hypochlorite into the downcomer tube from two pails.

FILTER PUMP. The pump is a centrifugal type pump. It is used to pump clear water from the wet well to the diatomite filter. It has a capacity of ten gallons per minute.

PIPES AND FITTINGS. The piping used on the unit is color coded. Black is for raw water, yellow for clear water, green for filtered water, and red for waste water.

ELECTRICAL BOX. The box on the unit holds all of the electrical components that are used on the unit.

The equipment that is used to support the operation of the unit is as follows:

DIATOMACEOUS EARTH FILTER. This type of filter uses diatomaceous earth. The filter is made up of the filter housing, precoat funnel, influent and effluent gauges, air release valve, filter elements, wash ring and rate of flow controller. The filter will remove any of the suspended matter that did not settle out.

GENERATOR. A 3-kw gas driven generator is used to provide power to the unit.

RAW WATER SUPPLY PUMP. The pump is the same type of pump as the filter pump. It is used to pump raw water from a lake or stream to the field water purification unit. It also pumps at a rate of 10 GPM.

WATER DISTRIBUTION PUMP. This pump is used to pump filtered water from the storage tanks to water trucks and tanks.

STORAGE TANKS. Two collapsible rubber tanks are used for the storage of filtered water.

STRAINERS AND HOSES. Strainers are used to keep large objects from entering the hoses. The hoses are used to allow water to flow from one place to another.

TEST EQUIPMENT. The chlorine residual test comparator is the only test equipment that will be with the unit.

Chemicals that are used on the field water purification unit are:

FERRIC CHLORIDE as a coagulant.

CALCIUM HYPOCHLORITE as a disinfectant.

DIATOMACEOUS EARTH as a filter aid.

ACTIVATED CARBON as an absorber to control bad taste and odors.

PULVERIZED LIMESTONE add salkalinity.

Read additional information on the purpose, components, support equipment and chemicals on the 600 GPH Unit in TO 40W4-9-1 on pages 3 to 10, Section II, paragraph 3.

OPERATION OF FIELD WATER PURIFICATION UNIT (ERDLATOR)

Pre-operational Inspection

The field water purification unit is set up and ready for operation. You must, as an operator, inspect and service this unit before you start it up, to make drinking water. Some of the things that are inspected on the unit are: all of the main parts of the unit, support equipment, tools, and chemicals. Servicing would include lubrication of specific components on the unit, preventive maintenance services, cleaning of unit, and checking any other parts of the unit which have not been looked at earlier. Read the more detailed checklist of inspecting and servicing the unit found in TO 40W4-9-1, page 26, paragraph 9b and page 35, para 11b. Do not read para. 17 and 48 at this time.

Pre-operational Procedures

The first item that is done is the preparation of the ferric chloride and calcium hypochlorite solutions. The chemical slurry feeder compartment is then filled with raw water. Next, all of the valves are positioned according to TO 40W4-9-1.

Operating Unit

The generator is inspected and then started. The raw water pump is primed with raw water. The chemical solution feeder is primed, rate set and then started. When there is one foot of water in the ERDLATOR tank, the agitator drive motor is started. When air is agitating the water in the slurry feeder, add limestone to it. When the water gets to the effluent launder, the efflent launder should be adjusted. Read additional information found in the TO on page 54 to page 60 and pages 48 and 49, para 29b.

Raw water is pumped directly from the source into the ERDLATOR assembly. It is introduced at the top of the ERDLATOR into the influent launder through the aspirators, which aerate the water. The water overflows from the influent launder into the mixing zone, where chemicals are added; ferric chloride, pulverized limestone, and calcium hypochlorite. When activated carbon is needed for a special purpose, such as decontamination or removal of taste or odor, it is also added here with the pulverized limestone.

As the water and chemicals descend through the mixing zone, they are thoroughly mixed by the motion of four flat circular disks located at equal intervals on the rotating agitator shaft, at the center of the coagulator. This flow is a downward rotation. At the bottom of the coagulator are shallow baffle which deflect the flow and reverse the flow of water.

The baffles direct the water into the clarification zone, the conical shaped area which surrounds the mixing zone. The water is forced downward in a counter-rotation at a reduced speed but continues with sufficient velocity to keep the slurry pool, rotating. The coagulants draw the solids into increasingly large particles which, because of their weight tend to rise more slowly than the clear water which goes to the top of the clarification zone. These actions which take place in the mixing zone and the clarification zone illustrate the term "solids contact" and "upward flow", used to describe the continuous flow in water purification units.

There is a distinct separation of the clear water in the separator zone and the slurry in the clarification zone. At the top of the separator zone, the clear water is collected by the effluent launder and is continuously drawn off and discharged into the "wet well" tank. There it is stored until it is delivered into the filter. Besides providng space for clarified water, the wet well tank also acts as a sump for the filter pump.

The sludge concentrator tank is attached externally to, and at one quadrant of the ERDLATOR. The sludge concentator tank funcitons as a small auxiliary clarifier. It draws slurry, still in the flocculent state, from the clarification zone, and provides a longer holding period for slurry concentration than does the clarification zone itself. The sludge concentrator tank also permits settling of sludge to the bottom of the tank for continuous or intermittent drainage to waste, and skimming of clear coagulated water at the top of the tank for return to the wet well. So far the water has been subjected to the processes of coagulation, floucculation sedimentation, and chlorination, by one continuous flow process. Further purification of the water is necessary. Remaining suspended solids must be removed by filtration.

Operating Diatomaceous Earth Filter

When the wet well tank is full and the water looks clear, the diatomite filter is put into operation. This is done first by positioning all of the valves. Add a diatomite slurry to the pre-coat funnel and turn the filter pump on. While water is pumped into the filter, air is escaping from a vent valve. This is done until water comes out, then the valve is closed. The water is then recirculated from the filter to the wet well tank, then back to the filter. This will put a fine coat of diatomite on the elements. When the elements are coated properly, valves are repositioned to filter water (produce clear water). The other slurry feeder box is filled with clear water and diatomite is added to lengthen the filter run.

Filtration and backwash procedures: A slurry of diatomite and water is introduced into the filter to precoat the system before the filter is put into operation. The diatomite is held and supported on the filter element by a pressure difference between the inside and outside of the filter element. The diatomite cake is maintained by the continuous addition of a small amount of diatomite into the slurry feeder. When the water pressure on the filter pump increases as compared to the low rate the filter is clogging and backwashing is necessary. To do this the air release valve is opened. The air pressure under the filter dome is thus suddenly released, allowing the air in the filter dome to escape and allowing the air in the filter elements to expand with the effect of a blast which knocks the diatomite and foreign matter off the filter elements. This is called backwashing by the air pump method. After the filter has been backwashed and drained, the filter pump should then be used to flush the filter before the unit is again precoated and put into operation. Read TO 40W4-9-1, pages 49 to 51, para 29c, Filtering Process.

There are several things that you will do while operating the field water purification unit. One of the first steps that will need to be done is the recharging of the chemical feeders. The slurry feeder needs to be recharged every hour. A timer will go off when the hour has passed. The solution feeder is recharged when the pails that contain the chemicals are low. The TO will tell you how much of each chemical to add. If the slurry blanket in the erdlator tank looks like it is going too fast, you must take corrective action. The slurry level must be kept at the draw off port and any excess slurry will be drawn off to the sludge concentrator tank. When this small tank is full, a valve is opened to waste. One of the main things that needs to be done is the backwashing of the filter. The filter is backwashed when:

The effluent pressure gauge drops down to five psi.

Large areas of the elements are not covered with diatomite.

The suspended solids are not removed from the filtered water.

The flow has stopped.

The backwashing steps are found in the TO. If these things are not done as the TO requires, the quality and even the quantity of water that you want to make will be affected. So it is very important that you follow these steps.

Shutdown of Unit

When you need to shut the unit down and move, a step by step procedure is found in the TO 40W4-9-1 on page 65 and 66 paragraph 33 and 34. Read this section before proceeding any further.

EXERCISE III-6-6b

PART I

INSTRUCTIONS

Identify the components of the following diagram by listing the correct name of each component accoridng to the figure item number. See figure 6-4.

Figure Item Number	Name of Component
1	
2	
3	
4	
5	
6	
7	
8	
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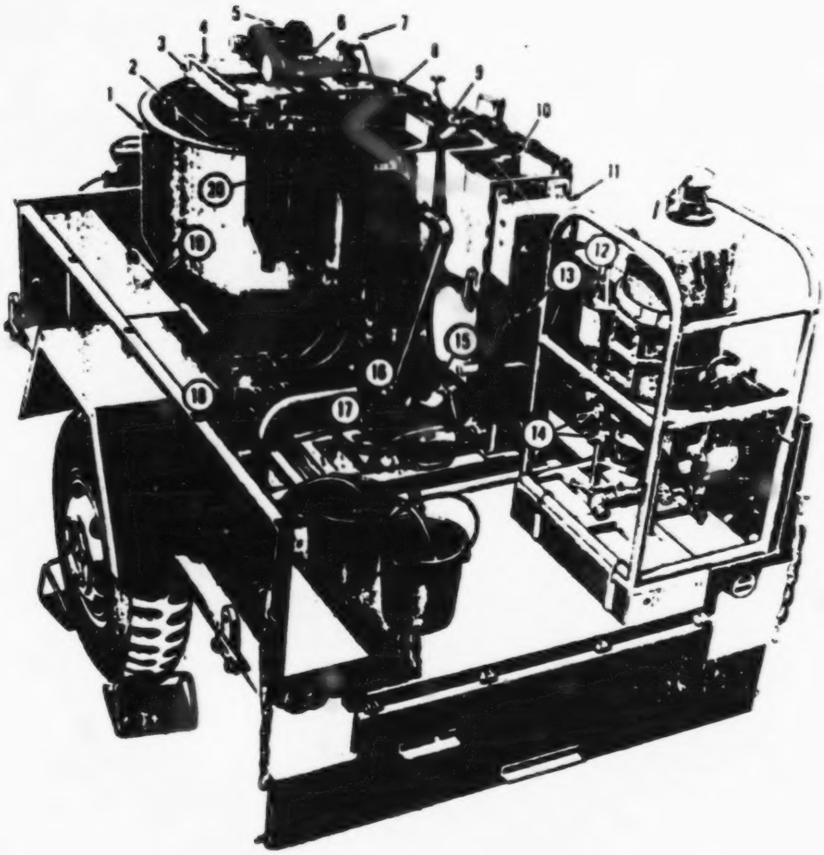
10	
11	
12	
13	
14	
15	



1	Erdlator tank	11	Electric control box
2	Effluent launder	12	Precoat funnel
3	Effluent launder adjustable support rods (3 rqr)	13	Power cable
4	Bridge rail	14	Pressure gage
5	Agitator drive motor	15	Filter pump
6	Speed reducer	16	Weir box
7	Air pump	17	Erdlator mix box
8	Influent launder	18	Chemical solution feeder
9	Wet well tank	19	Storage box
10	Sludge concentrator tank	20	Chemical slurry feeder

Figure 6-4. Erdlator Unit Mounted in Trailer

Filtration and backwash procedures: A slurry of diatomite and water is introduced into the filter to precoat the system before the filter is put into operation. The diatomite is held and supported on the filter element by a pressure difference between the inside and outside of the filter element. The diatomite cake is maintained by the continuous addition of a small amount of diatomite into the slurry feeder. When the water pressure on the filter pump increases as compared to the low rate the filter is clogging and backwashing is necessary. To do this the air release valve is opened. The air pressure under the filter dome is thus suddenly released, allowing the air in the filter dome to escape and allowing the air in the filter elements to expand with the effect of a blast which knocks the diatomite and foreign matter off the filter elements. This is called backwashing by the air pump method. After the filter has been backwashed and drained, the filter pump should then be used to flush the filter before the unit is again precoated and put into operation. Read TO 40W4-9-1, pages 49 to 51, para 29c, Filtering Process.

There are several things that you will do while operating the field water purification unit. One of the first steps that will need to be done is the recharging of the chemical feeders. The slurry feeder needs to be recharged every hour. A timer will go off when the hour has passed. The solution feeder is recharged when the pails that contain the chemicals are low. The TO will tell you how much of each chemical to add. If the slurry blanket in the erdlator tank looks like it is going too fast, you must take corrective action. The slurry level must be kept at the draw off port and any excess slurry will be drawn off to the sludge concentrator tank. When this small tank is full, a valve is opened to waste. One of the main things that needs to be done is the backwashing of the filter. The filter is backwashed when:

The effluent pressure gauge drops down to five psi.

Large areas of the elements are not covered with diatomite.

The suspended solids are not removed from the filtered water.

The flow has stopped.

The backwashing steps are found in the TO. If these things are not done as the TO requires, the quality and even the quantity of water that you want to make will be affected. So it is very important that you follow these steps.

Shutdown of Unit

When you need to shut the unit down and move, a step by step procedure is found in the TO 40W4-9-1 on page 65 and 66 paragraph 33 and 34.

INFORMATION

Preventive Maintenance and Troubleshooting

The maintenance of the upflow clarifier will be covered in two areas. Daily maintenance requirements and quarterly preventive maintenance service.

Daily Maintenance

These are task that must be done daily. These tasks are listed below with a brief explanation of each. You should use TO 40W4-9-1, Section III Preventive Maintenance Service for a more detailed explanation.

You will be given a copy of TO 40W4-9-1 to learn the following tasks:

VISUAL INSPECTION. Inspect for leaks, loose connections, any physical damage that may have occured since the unit was last used.

OIL. Check the oil level in each engine crank case.

DRAIN LINES. See that all drain lines are securely connected and not damaged. Make sure that the waste water is disposed of so it will not interfere with the operation of the unit.

UNUSUAL NOISES OR OPERATION. Inspect the electric motors for overheating. Inspect all drive belts to see if they are slipping. Check for any unusual noise that may indicate an operational problem.

LEAKS. You should inspect all hoses, connections, tanks, pumps, piping, and pipe fittings for any leaks.

CLEAN EQUIPMENT. Remove any oil, mud, grease, chemical or other foreign matter from external parts of the unit with clean cloths.

FILTERS AND TANKS. The operator should backwash the filters when the gauges show that it needs to be done. The storage tanks are checked for cover and security.

WATER TREATMENT EQUIPMENT. Drain and clean all parts of the unit on a regular basis.

Quarterly Preventive Maintenance Services.

Quarterly means every ninety (90) days. This section of the TO has the greatest amount of detailed maintenance required on the erdlator. The following tasks below are only a brief explanation of each. You will be given TO 40W-4-9-1 to perform your maintenance. Before operation you must inspect the unit.

LUBRICATION. Check all lubrication fittings and lubricate if needed with the specified grade of lubricant.

APPEARANCE. You must inspect the general appearance of the unit, check all markings, paint and cleanliness of the unit.

HOSES, PIPING, VALVES AND TANKS. These must be inspected for leaks and corrosion. Any part that is damaged or defective must be replaced.

CHEMICAL FEED EQUIPMENT. Inspect all of the different types of feed equipment that is being used. Check all of the main parts of these feeders for condition. Any part that is damaged or defective should be replaced.

FILTER AND FLOW CONTROLLER VALVES. The operator must check for any loose connections. Open and close all valves to see if they operate freely. You should check the proper flow rate of both the filter rate controller and the non-adjustable raw water controller valve.

FILTER ASSEMBLY. The operator will inspect for the following: dirty filter, leaky gaskets, broken window or elements, loose connections, insecure mounting and pressure gages.

DIATOMITE FILTER AIR RELEASE VALVE. The operator must inspect for any loose connections and signs of leakage near the flange bolts. You should tighten all loose connections and replace the air release valve if it is defective.

ELECTRICAL CONTROL BOX AND CONTROLS. The Operator should inspect the control box for insecure mounting. Inspect the warning buzzer, indicating light toggle switch, indicator light, receptacles, circuit breakers and transformer for damaged or defective parts.

LOW WATER LEVEL FLOAT ASSEMBLY AND EFFLUENT LAUNDER. The operator should inspect the wet well float assembly effluent launder adjusting rods and connecting tube, between the wet well and effluent launder for damage or cracks. You should tighten all loose connections and replace all defective parts.

CHEMICAL SLURRY AIR PUMP. The operator should check the air lines for damage and loose connections. Inspect the air pump for misalignment to the speed reducer, insecure mounting, leaks, and dirty filter element. You should repair, replace, clean, or tighten any component as needed.

AGITATOR DRIVE MOTOR. The operator will inspect for any misalignment between the motor and speed reducer, and for loose bolts on connections. You should listen for signs of worn bearings. The drive pulley is inspected for damaged parts. You should replace, tighten, or realign any component that is in need of maintenance.

LOW WATER LEVEL SENSITIVE SWITCH. The operator should inspect for loose connections and proper operation. You should clean, repair or replace any part as required.

SPEED REDUCER. The operator must inspect the speed reducer for loose connections and the drive belt for cracks and proper adjustment. The belt should have one inch of slack at a point midway between the pulleys. Remove and replace the drive belt and pulleys if they are defective.

RAW WATER AND FILTER PUMPS. The operator must inspect both pumps for loose mountings, corrosion, cracked housing, leaky seals, and damaged motor brushes. Tighten or replace any components as needed.

Read additional information in TO 40W4-9-1, pages 80 thru 85, para 47, 48, and 50.

Troubleshooting

During the operation of the ERDLATOR, many operational or mechanical problems may occur. The unit is usually in operation for most of the day or even the full 24 hours. Several days may elapse before shut down is practical. Continuous running of equipment will usually result in some type of maintenance requirement or malfunction. If for no other reason, the characteristics of the water source may change requiring you to adjust the chemical feed rates or filter run.

General troubleshooting information is located in TO 40W4-9-1, pages 85 thru 89, Section IV. Read this portion of the TO for further information.

EXERCISE III-6-6c

PART 1

INSTRUCTIONS

Using TO 40W4-9-1, fill in the blank spaces in the incomplete statements that pertain to preventive maintenance services.

1. Operation of the ERDLATOR must be ______________________________ if a deficiency is noticed which would damage the equipment.

2. Visual inspection for _________________, _________________, and ___________________ ____________________ should be performed daily.

3. Start the generator to see if the ERDLATOR is ___________________________________ _______________.

4. During operaton of the ERDLATOR the electric motor should be checked for ____________, the speed reducer drive belt for __________________, and the pump strainers for ____________________________.

5. During operation of the ERDLATOR, items to be checked for water leaks are: _______________, ____________, ________________, ______________, _______________, and ______________ ________________.

6. The D.E. filter should be ____________________ when the water flow through the elements have stopped.

7. After operation the water treatment equipment should be _______________ and ____________________ .

8. A good method to inspect a fire extinguisher for insufficient charge is by _________________ and _________________ it by sound and weight.

9. The chemical feed equipment should be inspected for ______________________ and a ____.

10. To check the adjustable flow control valve for proper feed, set the valve at a ________________ ________________ of flow and ____________________ the ______________________________ of the valve.

PRINCIPLES OF OPERATION OF THE REVERSE OSMOSIS WATER PURIFICATION UNIT (ROWPU)

Principle of Reverse Osmosis

OSMOSIS is a process which occurs in nature with all plants and animals. Osmosis is the process which occurs when there are two water solutions, one is high in solids and the other is low in solids. These solutions are separated by a membrane that will allow only the water molecules to pass through. The water that has a low contration of solids will flow toward the side which has a high concentration of solids. This osmotic pressure will equalize the dissolved solids on both sides of the membrane. Figure 6-7 shows the osmosis process. The movement of water through a permeable membrane from an area of lesser concentration to an area of higher concentration to equalize the concentration of the water on both sides of the membrane is called osmosis.

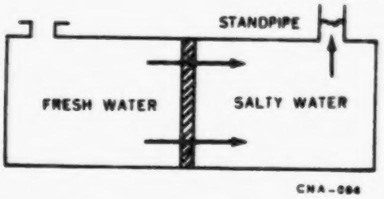


Figure 6-7. Osmosis

In the reverse osmosis process, pressure is applied to the water which is high in dissolved solids. This pressure forces this water through a semi-permeable membrane. This membrane allows the water to pass, but not the solids. The water on the other side of the membrane has little or no dissolved solids present. Figure 6-8 shows the reverse osmosis process.

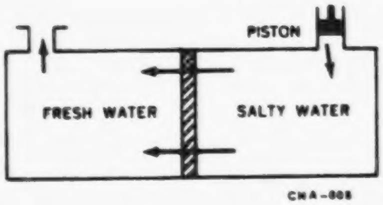


Figure 6-8. Reverse Osmosis

A reverse osmosis unit can remove 90 to 98 percent of all the dissolved solids and 99 percent of all the organic material in the water.

The semi-permeable membrane that is used in removing the dissolved solids from the salt water is made up of cellulose acetate and is only five thousanths of an inch thick. The membrane has two distinct layers. One layer is a spongy porous material which makes up 98.8 percent of the membrane. This was found to be highly permeable to both salt and water.

The second layer of the membrane is only ten millionths of an inch and actually seperates the salt from the water. When the water molecules reach this second layer, they actually dissolve into the membrane material, then diffuse or migrate through it as individual molecules and go into solution on the other side. The dissolved salt travels through the membrane at a rate that is much slower than the water. This is due to the solubility in the membrane material which is lower and because the mobility as dissolved molecules in the membrane is not as great as the water.

TYPES OF REVERSE OSMOSIS UNITS

There are two types of reverse osmosis units used at this time. They are the spiral module and the hollow fiber tube unit. The spiral module unit will be covered in the following paragraphs.

SPIRAL MODULE UNIT. This unit is made up of two layered membrane with a porous backing material between the layers which forms a sandwich. A perforated plastic pipe is placed at one end of the sandwich. The edges of the membrane are sealed with the porous backing material inside the resulting envelope. The edges of the membrane are sealed around the plastic pipe enclosing the porous material inside.

This membrane envelope, and a mesh spacer, is then rolled up onto the plastic pipe to produce a compact unit so that it will fit into a simple tubular pressure vessel.

At the open ends of the roll the mesh spacer creates a gap that will allow the feed water to pass axially through the roll. As the pressurized water flows through the mesh spacer passages, some of this water permeates or passes through the membrane and collects in the porous backing within the sealed envelope. The water spirals inward along the backing material to the center, out of the envelope through the pipe perforations, through the pipe and out of the module. As the water permeates or passes through the membrane the remaining feed fluid becomes more concentrated. This concentrated feed fluid continues to flow axially through the roll and emerges through the mesh spacer gaps at the other end. Figure 6-9 shows a typical spiral module unit set up.

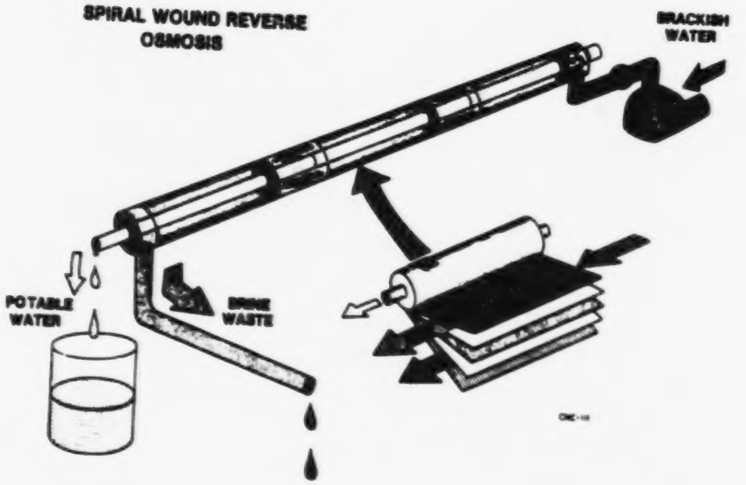


Figure 6-9. Typical Spiral Module

HOLLOW FIBER TUBE TYPE UNIT. This unit has approximately one million fibers bundled in a permeator or plastic pipe. Each fiber is approximately the same size as a human hair. Figure 6-10 shows a hollow fiber.

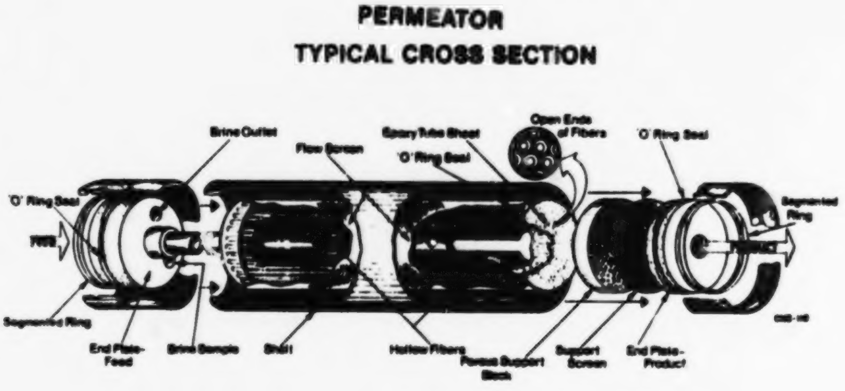

PERMEATOR
TYPICAL CROSS SECTION
Brine Outlet
Flow Screen
Epoxy Tube Sheet
'O' Ring Seal
Open Ends of Fibers
'O' Ring Seal
'O' Ring Seal
Segmented Ring
FEED
Segmented Ring
End Plate-Feed
Brine Sample
Shell
Hollow Fibers
Porous Support Block
Support Screen
End Plate-Product

Figure 6-10. Hollow Fiber

The feed water enters at one end of the permeator under pressure. The water is forced to go through the hair-like fibers. These hair-like fibers are very similar to the membranes in the spiral module unit. The suspended matter stays on the outside of these fibers while the water passes through the fibers free of suspended matter and flows out the other end. This water is called permeate.

The pressure applied should be in the range of 100 to 1500 pounds. The amount of pressure depends on the type of membrane used. Water will pass through the membrane leaving the solids behind. There is no chemical reaction involved, it is all mechanical.

Reverse osmosis has many applications and advantages such as:

1. Demineralizing sea water.

2. Softening of water.

3. Treatment of boiler feed water.

4. Portable water units.

5. Removing radioactive contamination.

6. Purifying industrial waste water.

7. Tertiary treatment of sewage.

Reverse osmosis is so efficient that some bacteria are filtered out and those that do pass through are easily destroyed by chlorination.

Some disadvantages of reverse osmosis are:

1. High initial cost.
2. Membranes coat easily with solids.
3. Turbid water must be filtered.
4. Requires high pressure source.

Read T.O. 40W4-13-1, Chaper 1, Section I and II, para 1-5, Equipment Characteristics, Capabilities and Features.

Components of the R.O. Unit

INFORMATION

Read T.O. 40W4-13-1, Chapter 1, Section II, para. 1-6, pages 1-2 thru 1-12, Location and Description of Major Components.

Principle Operation of the Components

INFORMATION

The operator of a reverse osmosis unit must use the manufacturer's manual for proper and safe operation of the unit. Each unit will be different in design and operation. As an operator, you must use the correct manual.

Read T.O. 40W4-13-1, Chapter 1, Section III pertaining to the principles of operation of a R.O. unit.

Chemicals

INFORMATION

Read T.O. 40W4-13-1, Chapter 1, Section III, and Chapter 2, Section III, pages 2-45 thru 2-47 pertaining to chemicals used with the R.O. unit.

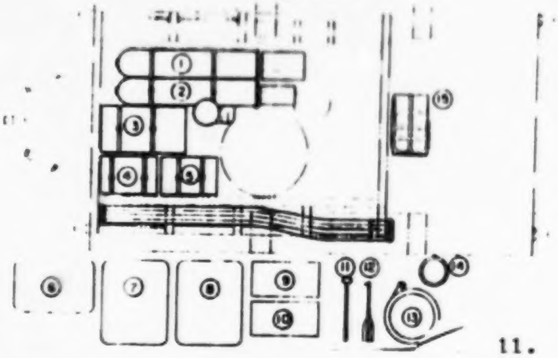
EXERCISE III-6-6d

PART 1

INSTRUCTIONS

Use T.O. 40W4-13-1, to complete the identification of the R.O. components from diagrams 1 and 2.

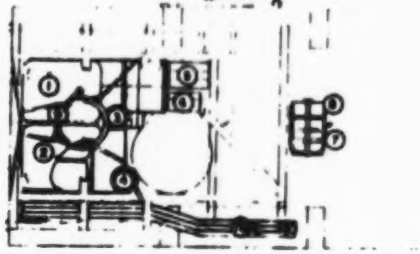
Diagram 1



1. NBC tank
2. NBC tank
3. Backwash pump
4. and 5. Raw water pumps
6. Brine tank
7. and 8. Product water tanks
9. and 10. Storage boxes 1 and 2

11. Sledge
12. Paddle
13. Rubber hose
14. Utility pails
15. Distribution pump

Diagram 2



Legend

1. and 2. Tanks
3. Float
4. Pails
5. and 6. Canvas hoses

7. Ladder
8. Distribution pump
9. Suction hose
10. Hard rubber hose

Storage box No. 1 contains:

(1) Turbidity tube.

(2) Input strainer.

(3) Distribution nozzle.

(4) Thermometer.

(5) Flashlight, drop cord, and lamps.

(6) Tools and spanner wrenches.

(7) TDS Meter

(8) Chemical measures (cylinders).

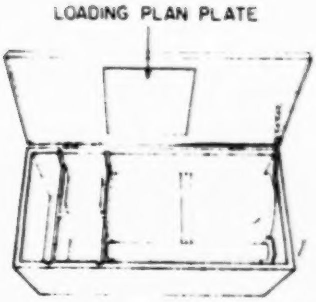
(9) Tape for wrapping on pipe threads.

(10) Hose-reducing nipples.

(11) 100-watt light bulb.

(12) R.O. vessel end cap pullers.

(13) R.O. pump valve seat tools.



STORAGE BOX
NO. 1

The other (storage box No. 2) contains:

(1) Chemical feeding tubes.

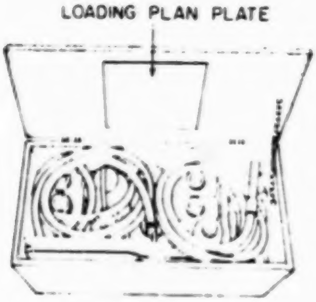
(2) Chemicals.

(3) Water testing kit.

(4) Chemical mixing wooden paddles.

(5) Color comparator kit.

(6) 100-ml plastic cylinder.



STORAGE BOX
NO 2

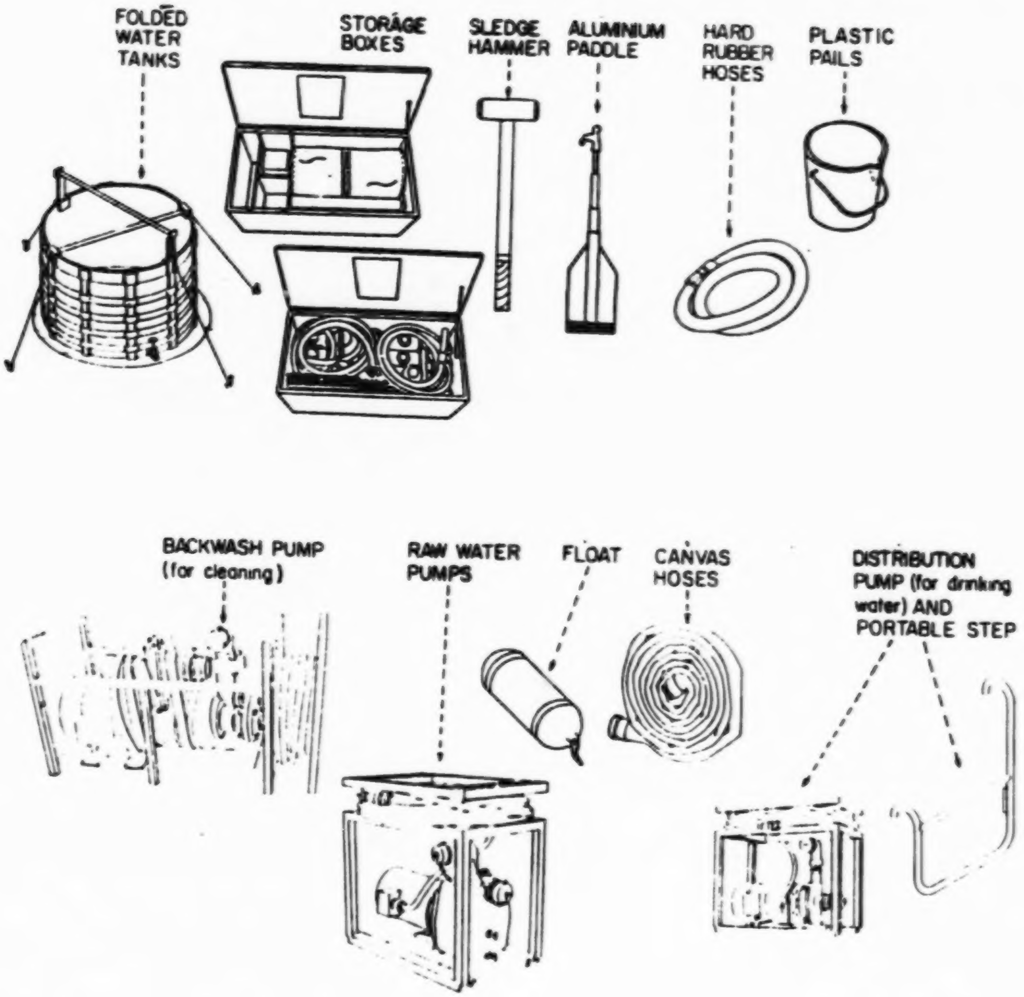

FOLDED WATER TANKS
STORAGE BOXES
SLEDGE HAMMER
ALUMINIUM PADDLE
HARD RUBBER HOSES
PLASTIC PAILS
BACKWASH PUMP (for cleaning)
RAW WATER PUMPS
FLOAT
CANVAS HOSES
DISTRIBUTION PUMP (for drinking water) AND PORTABLE STEP

Figure 6-11. ROWPU, Pumps and Equipment Identification

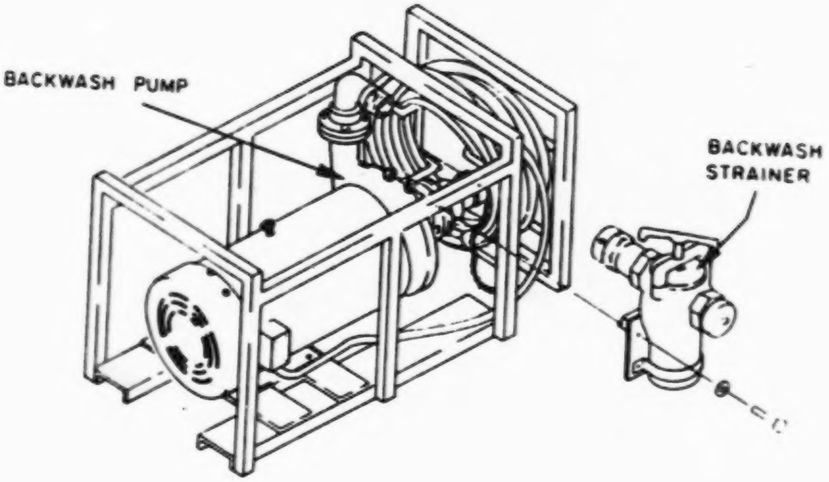
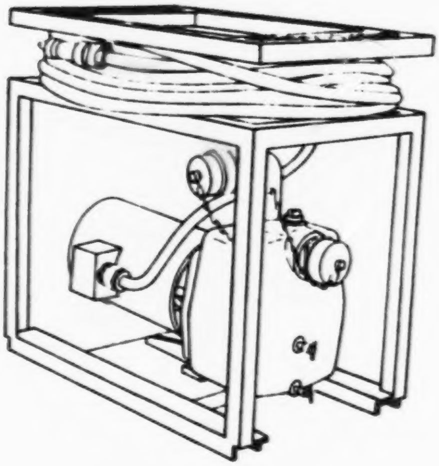
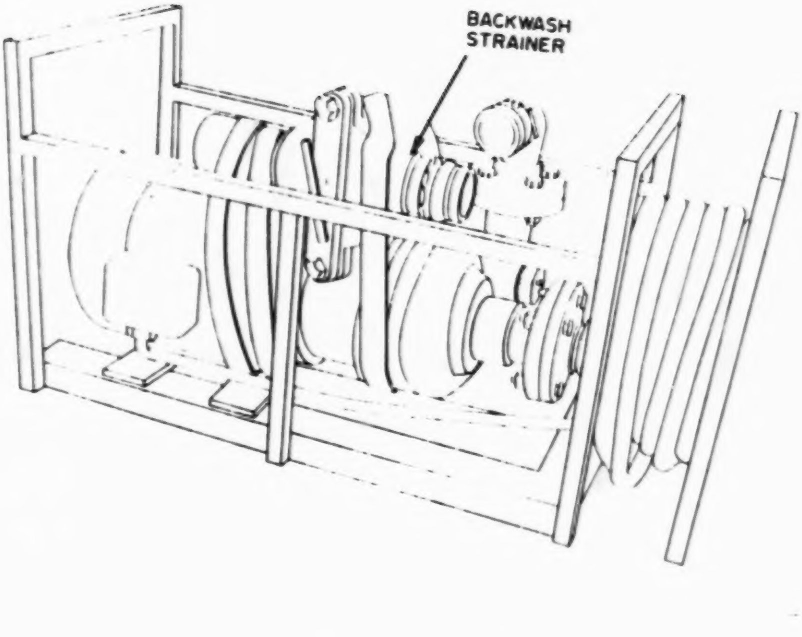

BACKWASH PUMP
BACKWASH STRAINER

Figure 6-12. Backwash Pump and Strainer



RAW WATER PUMP (2 USED)


BACKWASH STRAINER

BACKWASH PUMP

Figure 6-13. Raw Water and Backwash Pumps

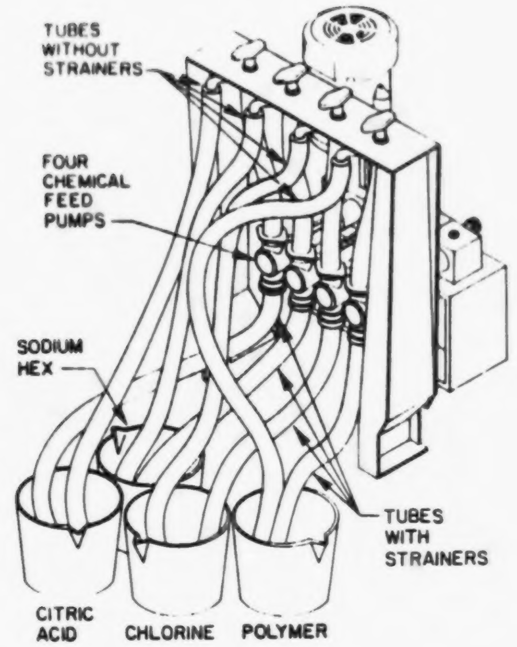
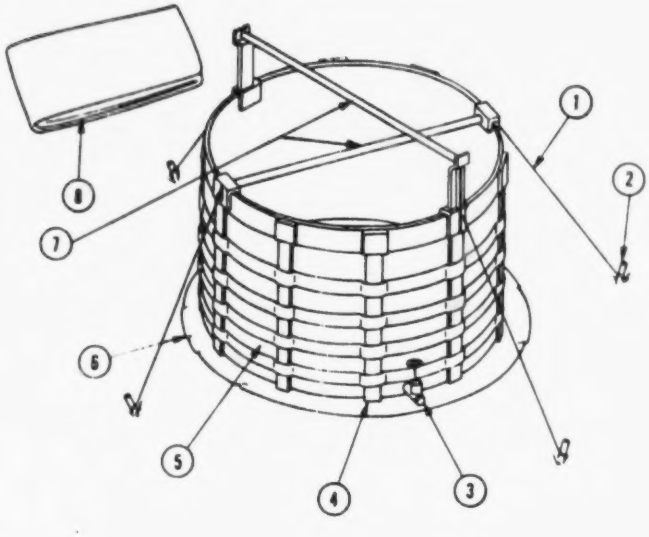
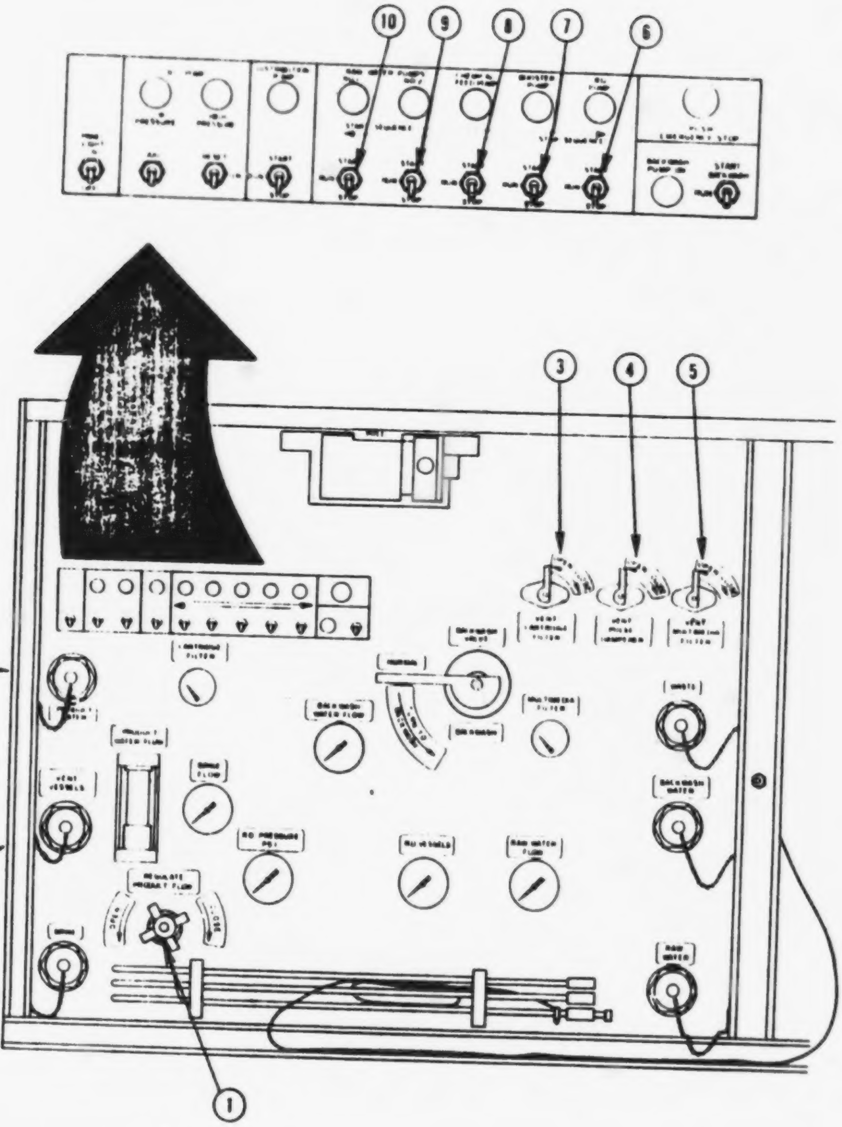

TUBES WITHOUT STRAINERS
FOUR CHEMICAL FEED PUMPS
SODIUM HEX
TUBES WITH STRAINERS
CITRIC ACID
CHLORINE
POLYMER

Figure 6-14. Tubes Attached to Chemical Feed Pump



1. Guy rope
2. Anchor stake
3. Outlet
4. Wood Stave
5. Tank
6. Ground cloth
7. Spreader bars
8. Cover

Figure 6-15. Collapsible Tank Installation



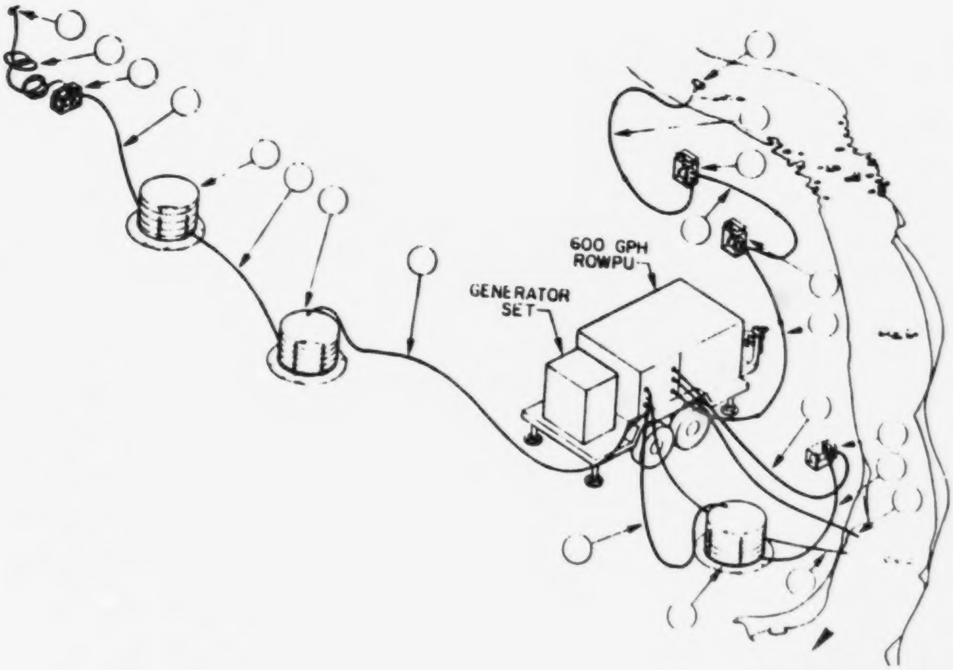
Order	Valve or Switch
1.	REGULATE PRODUCT FLOW valve
2.	VENT VESSELS valve
3.	VENT CARTRIDGE FILTER valve
4.	VENT PULSE DAMPENER valve
5.	VENT MULTIMEDIA FILTER valve
6.	R.O. PUMP switch
7.	BOOSTER PUMP switch
8.	CHEMICAL FEED PUMP switch
9.	RAW WATER PUMPS NO. 2
10.	RAW WATER PUMPS NO. 1
11.	VENT PRODUCT WATER valve

Figure 6-16. Control Panel Switches and Valves

PART 8

INSTRUCTIONS

Complete the following diagram by identifying the components and units of a typical field water installation set up of a R.O. field water plant system.



R.O. COMPONENT LIST

1. Float and strainer
2. Three 1 1/2 inch hard rubber hoses
3. Raw water pump
4. Two 1 1/2 inch hard rubber hoses
5. Raw water pump
6. Three 1 1/2 inch canvas hoses
7. Backwash canvas hose
8. Backwash pump
9. Backwash 2 inch hard rubber hose
10. Wastewater 2 inch canvas hose
11. Vent vessels
12. Collapsible 1500 gallon brine tank
13. Brine 2 inch canvas hose
14. Two 1 1/2 inch hard rubber hoses
15. Collapsible 1500 gallon product tank
16. Product water 1 1/2 inch hard rubber hose
17. Collapsible 1500 gallon product tank
18. Product water 1 1/2 inch hard
19. Distribution pump
20. Product water 1 1/2 inch canvas rubber hose
21 Distribution nozzle
22. Product water 1 1/2 inch canvas hose
23. Distribution nozzle

Typical Field Installation

Preventive Maintenance

INFORMATION

During the operation of the R.O. unit, several operational or mechanical failures could occur. The unit is usually in operation most of the day, if not all day. Continuous running of the R.O. unit does put a strain on the components of the unit. To insure minimum down time of the R.O. unit and its components, proper preventive maintenance procedures must be followed. Information pertaining to preventive maintenance is written in T.O. 40W4-13-1.

INSTRUCTIONS

PART 1

Read T.O. 40W4-13-1, Chapter 2, Section II, pages 2-15 thru 2-26 and complete the following exercise pertaining to preventive maintenance of the R.O. unit.

EXERCISE III-6-6e

1. What preventive maintenance is performed on the frame and R.O. equipment?

2. What action should be taken if raw water will not flow through the multimedia filter?

3. The chemical feeder pumps are not supplying feed to the unit, what is the most probable cause(s)?

4. What action should be taken if the chemical feed motor will not operate?

5. What should be checked if the R.O. pump or motor does not operate?

6. What preventive maintenance procedure should be taken if the raw water pumps or booster pumps do not work?

7. You notice the multimedia filter did not complete the backwash cycle, what action should be taken to insure the backwash times will work?

____

8. What action should be taken if you notice that a R.O. vessel is cracked, broken or leaks around the seals?

____

____

9. Before operation, you notice that a circuit breaker is hard to operate; what action should you take?

____

____

10. What preventive maintenance is required on a high-pressure relief valve?

____

____

SUMMARY

Water for military use must be treated to the degree required and be free of disease-producing organisms, poisons, and CBR agents along with excessive amounts of organic matter, minerals, salts, and turbidity. Odor and color should be removed and the water should be cool and clear for consumption. Field units such as the ERDLATOR and ROWPU are used for contingency operations to provide safe, pleasant water. Sources of water are important considerations and the characteristics of water must be known. Water reconnaissance, site selection and development are essential for good, safe working conditions. Equipment must be operated and maintenance must be performed to process safe water for a required demand. Once you have been awarded a 5-skill level, you may return for the advanced 5-level courses which pertain to the set-up operation and troubleshooting of both field water purification units.

REFERENCE

T.O. 40W4-13-1

636

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

SWIMMING POOLS

OBJECTIVES

Using information from AFR 91-26 relating to the operational principles of swimming pools, match the facts and terms to the identifying statements. Eight of the twelve matched statements must be correct.

While at the base swimming pool, identify the construction features and major components of the pool by making written responses to complete a diagram. Fifteen of the twenty responses must be correct.

While at the base swimming pool and given information, list the maintenance requirements of the pool. No more than one instructor assist is allowed.

INTRODUCTION:

All Air Force bases have swimming pools for Air Force personnel and their families to use and enjoy on their off duty time. If germs or sick people are in the pool, it may lead to the spread of diseases. Contaminated pool water may cause the following: colds, respiratory infections, typhoid fever, cholera, infectious hepatitus, intestimal disorders, and eye, ear, nose, and throat infections. The Air Force needs skilled pool operators to stop the spread of these diseases and to keep the equipment operating properly.

The water in a swimming pool must not be cloudy. It would be hard for a lifeguard to see a swimmer that is struggling in cloudy water. Not too many people would like to swim in a pool that has a cloudy appearance, the water must be clear and attractive.

The pool operator must ensure that the equipment is in its best possible operating condition. First, if the equipment is operating properly, the quality of the water should be clear. Second, the proper operation of the equipment saves money by the elimination of the following pool maintenance items. Excessive chemical use, the replacement of worn parts, and frequent dumping and refilling of the pool. To keep these conditions from occuring the pool operator must follow the proper operating and maintenance procedures.

PRINCIPLES OF OPERATION

Source of the Water

The water that is to be used in an Air Force swimming pool must be approved by the base medical personnel. Water is added to a pool either in the deep end just above the surface of the pool or in a make up tank. The method that is used to add the make up water depends on the type of filtration system that is used.

TURBIDITY. Turbidity is the suspended dirt, undissolved chemicals, algae or any other material that is in the water. This will cause the cloudiness in the pool water, which is not attractive in appearance. Not only would it be unattractive, but safety factors would be involved. A swimmer that is struggling to keep from drowning, has a hard time seeing where to go. The turbid water would prevent people from seeing underwater objects and other bathers. To determine if the water in the pool is turid, a six inch black disc is used. It is placed in the deep end of the pool, normally ten feet from the edge. If the disc appears cloudy, then backwash the pressure sand or diatomaceous earth filter. If an antracite or gravity sand filter is used aluminum sulfate, a coagulant, is added before the filter. This will aid in the removal of suspended particles.

TEMPERATURE. The temperature of the water at an outdoor pool will be affected by the air temperature. It is very difficult to control the temperature of this type pool. The temperature of the water at an indoor pool shall not exceed 78 degrees F. The air temperature of an indoor pool which is heated by an external source, shall not be more than 5 degrees warmer nor more than 2 degrees cooler than the water in the pool. It would be ideal for the air temperature to be 5 degrees warmer.

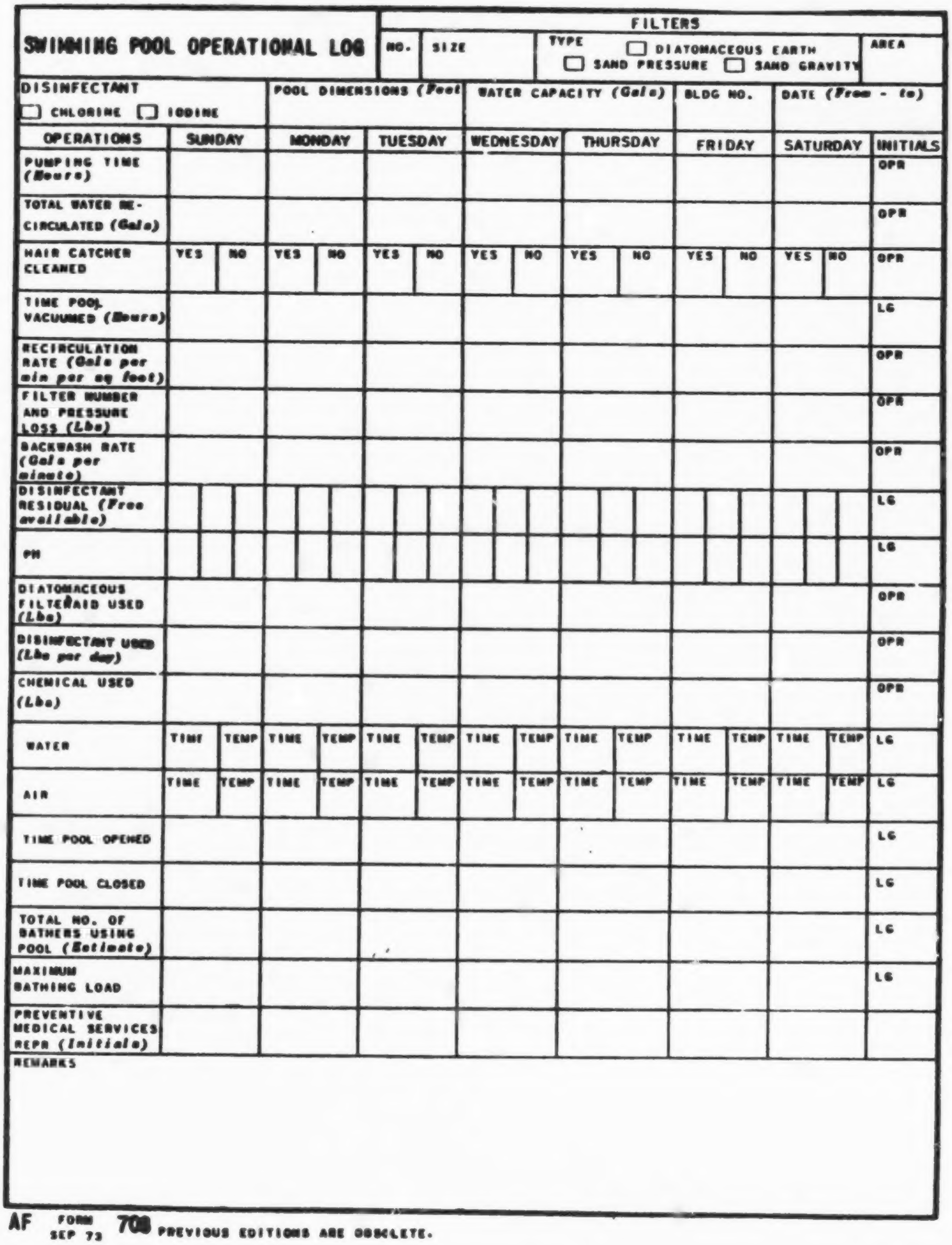
pH. The water in the pool shall be made slightly alkaline, so the pH shall between 7.2 to 7.8. The pH test is taken from the ends of the pool every three hours and the results are recorded on AF Form 708. When the pool operator performs this test, AFM 85-13 should be used for the proper testing procedure.

If the water is too acid, the eyes and skin of the bathers will burn and it will also corrode the pool piping. If the water is too alkaline, the bathers skin will be irritated. High alkalinity hinders disenfection of the water in addition it causes scale deposits in pipes and filters. To adjust the pH the pool operator should add soda ash or lime to the influent line or the pool filter.

CHLORINE RESIDUAL. Maintaining the chlorine residual is a very important factor in the operation of an Air Force swimming pool. Since 20 to 30 percent of the bacteria is not removed by the filters, it must be eliminated by using chlorination. It is very important that the chlorine residual be kept at the proper level. The free available chlorine residual must be kept between 0.4 to 0.6 ppm. The test is made every hour. To make the test, take samples from all four corners. The test results are recorded every three hours of AF Form 708. The pool operator should use the procedures in AFM 85-13, and use the reagent that is the test kit.

POOL SANITATION. Foreign matter such as sand, grass, leaves and dust may be tracked into the pool by bathers or blown in by the wind. DO NOT permit direct access to the pool from unpaved areas. Bathers or operators should clean, spray or shower their feet or footwear.

AF Form 708. The pool operator at a base pool must fill out an AF Form 708 each day. Good and accurate records are very important to the operation of the pool. It ensures that routine tasks are being done on time and shows any problem in the operation. It also aids in the detection of the causes of these problems. The form also helps when you find false readings and any equipment malfunction that may result because of them. In addition, this form keeps a record of the chemicals and the quantity of water used. Figure 7-1 shows AF Form 708.



SWIMMING POOL OPERATIONAL LOG

FILTERS

NO. | SIZE | TYPE ☐ DIATOMACEOUS EARTH ☐ SAND PRESSURE ☐ SAND GRAVITY | AREA

DISINFECTANT ☐ CHLORINE ☐ IODINE

POOL DIMENSIONS *(Feet*

WATER CAPACITY *(Gals)*

BLDG NO.

DATE *(From - to)*

OPERATIONS	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	INITIALS
PUMPING TIME *(Hours)*								OPR
TOTAL WATER RE-CIRCULATED *(Gals)*								OPR
HAIR CATCHER CLEANED	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	OPR
TIME POOL VACUUMED *(Hours)*								LG
RECIRCULATION RATE *(Gals per min per sq foot)*								OPR
FILTER NUMBER AND PRESSURE LOSS *(Lbs)*								OPR
BACKWASH RATE *(Gals per minute)*								OPR
DISINFECTANT RESIDUAL *(Free available)*								LG
PH								LG
DIATOMACEOUS FILTERAID USED *(Lbs)*								OPR
DISINFECTANT USED *(Lbs per day)*								OPR
CHEMICAL USED *(Lbs)*								OPR
WATER	TIME TEMP	TIME TEMP	TIME TEMP	TIME TEMP	TIME TEMP	TIME TEMP	TIME TEMP	LG
AIR	TIME TEMP	TIME TEMP	TIME TEMP	TIME TEMP	TIME TEMP	TIME TEMP	TIME TEMP	LG
TIME POOL OPENED								LG
TIME POOL CLOSED								LG
TOTAL NO. OF BATHERS USING POOL *(Estimate)*								LG
MAXIMUM BATHING LOAD								LG
PREVENTIVE MEDICAL SERVICES REPR *(Initials)*								

REMARKS

AF FORM SEP 73 **708** PREVIOUS EDITIONS ARE OBSOLETE.

Figure 7-1. AF Form 708

Seasonal Care

OPENING OF BASE POOL FOR THE SEASON. Before an Air Force pool opens it must be inspected for several areas such as components, supplies, and pool areas. The filters should also be checked for any defects. If any are found, the pool operator should correct the problem. The chemical feeders should be operated to ensure that they are in good working order. Take an inventory of all the chemicals that are present. The pool should be drained, if not already, and scrubbed with a solution of hypochlorite. If the pool is in need of new paint, this should also be done.

Once all of the work has been done to the pool, the pool should be filled with water. The filter and chlorine feeder are started as soon as the pool is full. When the pool is full of water and operating, the chlorine, pH, and turbidity tests are made. The base swimming pool shall not be opened until all readings are acceptable and the base medical authority approves of the conditions of the water.

DAILY OPERATIONAL PROCEDURES. If the pool filter is in need of being backwashed, it should be done while the pool is closed. Remove any foreign matter such as rocks, sand, and leaves from the pool. If there is scum floating on top of the pool water, this can be removed by overflowing or flooding the pool. As the water level is raised, the excess water flows into the troughs. The pool operator should ensure that the chlorine residual, pH, temperature and turbidity are within the proper limits. To do this, make the tests at the proper times. If the chlorine residual is either low or high, the pool operator should adjust the chlorinator until the chlorine is at the proper level. If the pH is not within the 7.2 to 7.8 limits, add soda ash or lime to the pool water. Adjust the pool heater if the temperature of an indoor pool is not at 78 degrees F. If the pool operator observes that the six inch black disc appears to be cloudy, the filter needs to be backwashed. The operator should go by the S.O.P. (Standard Operating Procedure). The S.O.P. is a guide for the pool operator to use when either operating or backwashing the filter. The pool personnel should perform all of the required maintenance such as corrosion control on pipes, valves, and filters; changing the buckets on the hair catcher; and lubrication of pumps and motors. The operator must ensure that all the chemicals he needs are in stock and he must reorder if the stock is low. A good housekeeping routine should be performed everyday in all rooms.

SHUTDOWN OF THE POOL AFTER THE SEASON. When the pool is to be closed down for the season, the filters must be backwashed. Normally, a pool is drained for the winter. This would also include the pipes and valves. If the shell of the pool will float up, then maintain a desired level of water. To prevent any damage to the pool that would be caused by ice, logs should be placed in the pool.

Safety

Chlorine gas is a very poisonous gas which has a stiffling and suffocating effect when it is inhaled into the lungs. The pool operator must be sure that chlorine leaks do not cause a hazard. To keep this from occurring, a ventilation fan should be provided and it must be in good operating condition. The opening to the system will be located near the floor. This is due to the fact that chlorine gas is heavier than air. The switch to the fan should be located outside the chlorine room so that it can be reached in an emergency.

All the chlorine cylinders, both full and empty shall be chain locked to keep them from being knocked over. Daily, the pool operator should test all of the connections on both the chlorinator and cylinders for chlorine leaks. To find if chlorine gas is present, hold an open bottle of ammonia water near each connection. If a leak is present, a gray or white cloud will form. The strength of the ammonia should be checked from time to time to determine if the solution is strong or weak. If it is weak, it must be replaced with a new bottle.

The color that the pool is painted should contrast for ease of identifying the bathers. This would include both the walls and bottom. The racing lane markers should be no more than two inches in width. If the lane markers are more than two inches in width, it would be hard for a lifeguard to spot a struggling swimmer. The depth markers are placed on both the sides and deck. These numbers shall be placed at the points where the pool slopes deeper.

The pool operator must be sure that reach poles, floats, ropes, and any other safety equipment is easy to get to in case of an emergency. A telephone will be placed in a central location and a list of all emergency phone numbers will be posted nearby. There must be a first aid room which will have a first aid kit, with cots and blankets.

INFORMATION

CONSTRUCTION FEATURES

Types of Pools

The types of pools the Air Force uses varies due to several factors such as the location of the pool, climate, and the source of water. Circulating type pools are used mainly by the Air Force.

CIRCULATING POOLS. In circulating pools, the water is constantly removed from the pool, filtered to remove suspended matter, disinfected to remove any pathogenic organisms, then made slightly alkaline for the proper pH and pumped back into the pool. Water is added as needed to make up for losses due to several factors such as evaporation, leakage, and overflow.

The Air Force uses this type of pool since it is the most sanitary, and also the most economical. There are three main types of circulating pools; overflow trough, deck level and wading.

OVERFLOW TROUGH POOLS. With this type of pool, a continuous trough with a drain in the bottom is built inside the walls of the pool. As the filtered water is added or bathers splash water out of the pool, water overflows into the trough. This water contains most of the floating debris, spit, and mucus in the pool. This water is either returned to the filters or in some pools, it is discharged to waste. In some cases, all of the water msut be returned to the filters. The troughs not only remove objectionable material, but they also act as a hand hold for the swimmers.

DECK LEVEL POOLS. With this type of pool, the water level is maintained up to the level of the surrounding pavement. There are no overflow troughs used, but the paving around the pool slopes up from it into a "V" shaped trough with a drain in the bottom of it. As the water overflows across a portion of the paving to the bottom of the "V", the water is either discharged to waste or returned to the filters. This will depend upon the design of the pool.

The advantages of using the deck level pool are as follows: (1) easier to keep clean, (2) cost less to build, (3) offers a greater depth of water for the same depth of excavation. The main disadvantage of this type pool is that a lot of water gets on the deck. If this happens, then a rectangular drain with a grating for a cover must be used.

WADING POOLS. These pools are small pools for children to swim or play in. These small pools are much harder to maintain than swimming pools. The pool operator should make the same tests as for the swimming pool. The operation is very similar to that of the swimming pool.

MAJOR COMPONENTS

Hair catcher

The water that is going to the filtration system, must pass through a hair catcher. The purpose of the hair catcher is to remove hair, lint, and other large bits of foreign matter. The hair catcher is installed in the effluent line on the suction side of the pump. The hair catcher consists of a wire mesh or a slotted metal bucket. Figure 7-2 shows the hair catcher and figure 7-3 shows where the hair catcher is located in a typical pool.

Pumps and motors

A centrifugal pump is used to pump the water through the filtration system. These pumps are driven by an electric motor. There may also be a diesel engine for a stand-by power source. This will provide power in the event of a power failure. These pumps must be built so that the pool water can be filtered every six to eight hours. Figure 7-3 shows where the pump and motor is located at a typical pool.

Filters

Once the pool water has passed through the hair catcher and the filter pump, it will then go through the filtration system. The purpose of the filter is to remove not only suspended matter, but also very fine particles from the pool water. The Air Force primarily uses two types of filters. These two are rapid or pressure sand and diatomaceous earth. There are also two types of pool filters which are not used much at the present time. They are gravity sand and anthracite filters.

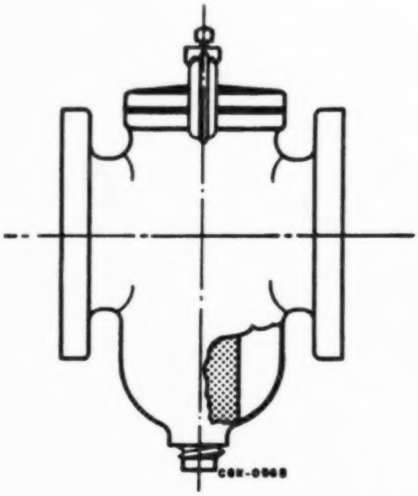


Figure 7-2. Hair Catcher

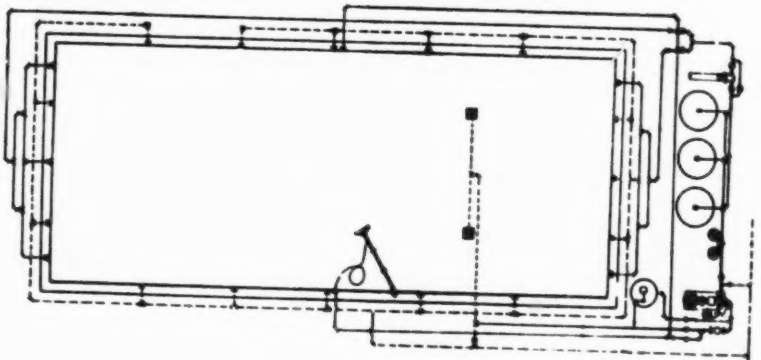


Figure 7-3. Typical Pool Installation

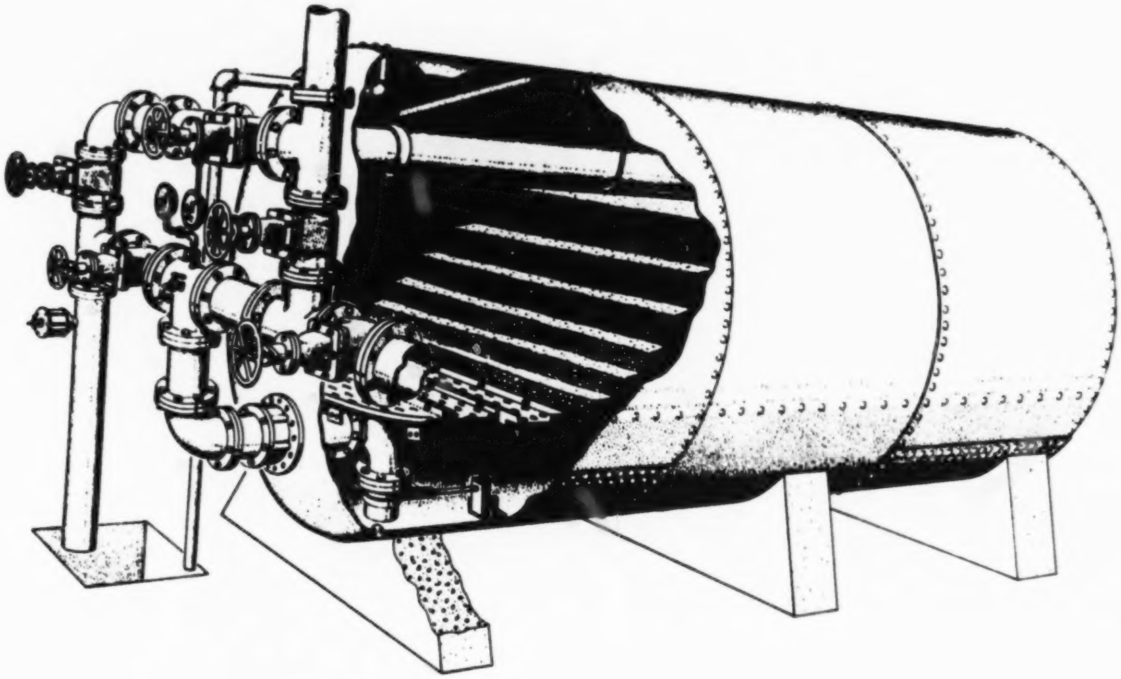


Figure 7-4. Pressure Sand Filters

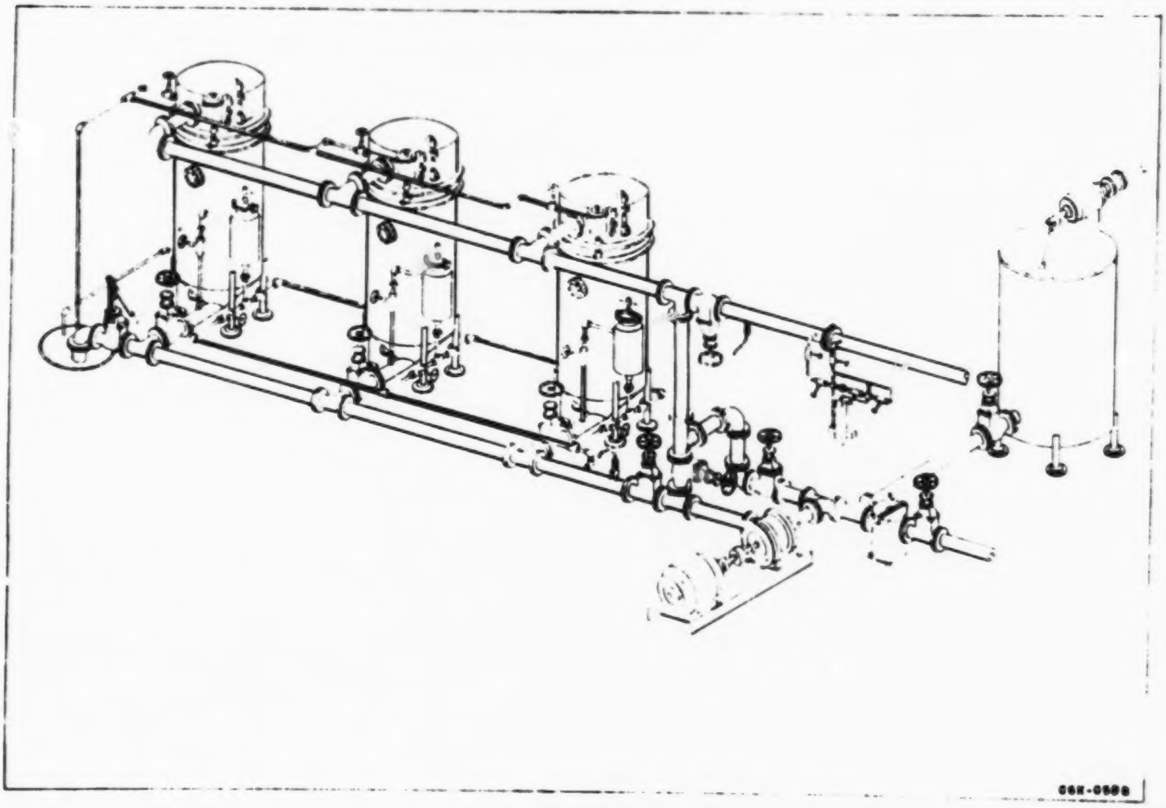


Figure 7-5. Diatomaceous Earth Pressure Filter

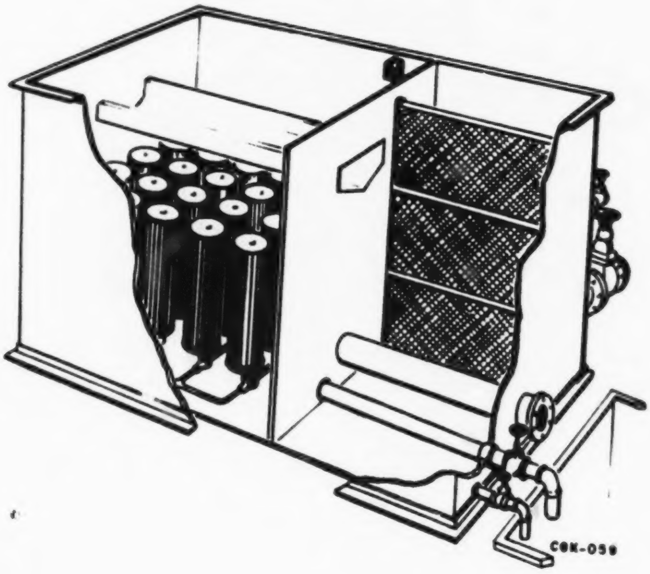


Figure 7-6. Vacuum Type Diatomaceous Earth Filter

PRESSURE SAND FILTERS. This type of pool filter is the same kind that is used in the treatment of drinking water. The operational procedures and the backwashing steps are the same also. There are two types of pressure and filters, horizontal and vertical. Figure 7-4 shows the horizontal type.

DIATOMACEOUS EARTH FILTER. The Air Force uses this type of filter for several reasons. First, the filter needs less space to operate than a pressure sand filter of the same capacity. Second, the diatomaceous earth filter produces a better quality of water than a pressure sand filter. There are two types of diatomaceous earth filters: pressure and vacuum.

PRESSURE TYPE FILTER. This type of filter has elements that are inside a sealed tank. When the filter is in operation, it is pressurized. This type of filter process is very similar to those used to treat municipal water. The operational procedures are also very similar. The pool operator should backwash when there is a pressure drop of 35-50 psi between the filter gages. This figure may vary since those units are made by several different manufacturers. Figure 7-5 shows the pressure type of D.E. filter.

VACUUM TYPE FILTER. This type of filter has an open tank with the elements attached to the bottom of the tank. The filter pump is on the effluent side of the filter. This allows the water to be sucked through the elements instead of being pushed. The backwash rate is 8 to 9 psi loss unless the manufacturer states otherwise. Figure 7-6 shows the vacuum type D. E. Filter.

Read AFM 91-26, Chapters 10 and 11.

Gauges

Pressure gauges are used on both the rapid sand and diatonaceous earth filters. These gauges are important for two reasons; they insure the proper operation of the filter and show when the filter needs to be backwashed. A pressure gauge is also used on the haircatcher. This gauge is found on the discharge side of the haircatcher and shows loss of head as the haircatcher becomes clogged.

Meters

The rate of flow meter is found on the discharge side of the filter and is used to control and maintain the proper filter and backwash rates.

Rate Controller

Rate of flow controllers are used in large pools. The controller keeps the same flow rate into and out of the filter. Figure 7-7 shows a rate of flow controller.

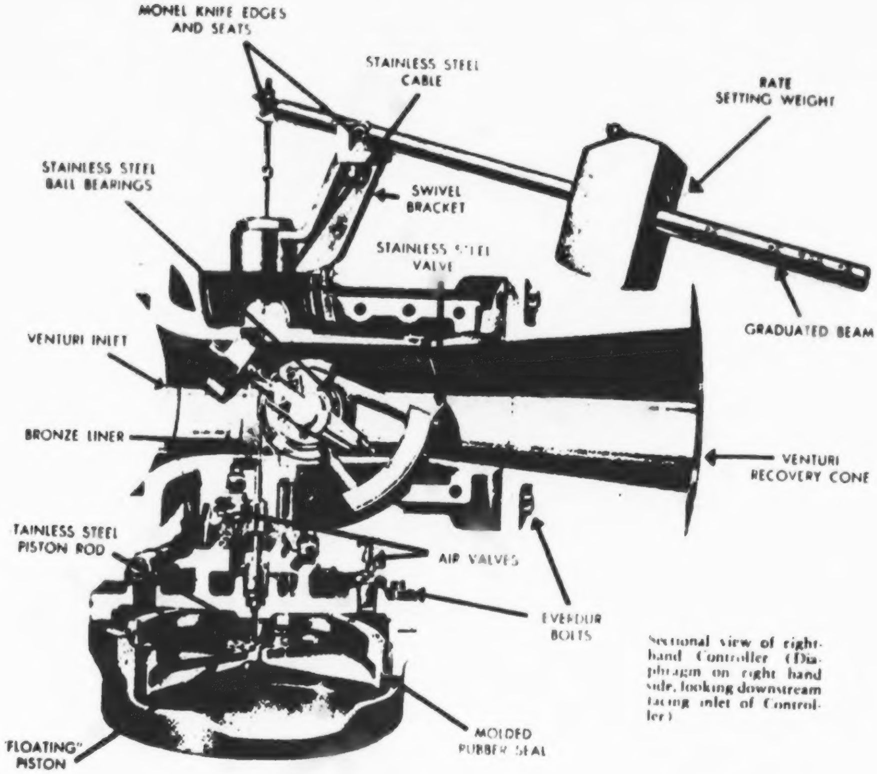

MONEL KNIFE EDGES AND SEATS
STAINLESS STEEL CABLE
RATE SETTING WEIGHT
STAINLESS STEEL BALL BEARINGS
SWIVEL BRACKET
STAINLESS STEEL VALVE
GRADUATED BEAM
VENTURI INLET
BRONZE LINER
VENTURI RECOVERY CONE
TAINLESS STEEL PISTON ROD
AIR VALVES
EVERDUR BOLTS
Sectional view of right-hand Controller (Diaphragm on right hand side, looking downstream facing inlet of Controller)
MOLDED RUBBER SEAL
"FLOATING" PISTON

Figure 7-7. Rate-of-Flow Controller

Water Return Inlets

Once the water has gone through the filter, it must be put back in the pool, in a way that will evenly mix the water. These inlets are located on the pool wall and are evenly spaced. Each inlet can be adjusted to control the amount of water that flows through it. When these inlets are set properly, the water enteres the pool in a uniform manner. Also with these inlets adjusted, the water is well mixed to maintain a uniform pH and chlorine residual throughout the pool.

Water Heater

These heaters are used to heat up the water at indoor pools. They are used to heat the water after it has passed through all of the treatment process. There are many types used including the steam type.

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Maintenance

AFR 91-26 should be used when maintaining the pool and its components. The pool should be kept clean at all times. The pool floor should be vacuumed; sides free of dirt and scum; and water clear and clean. The pumps and motors at the pool will be checked in the same way they are at a water plant. There should be two hair catchers for easier maintenance. One bucket can be cleaned while the other is in use. These buckets should be cleaned at least once a day. To aid the pool operator, a pressure gauge is found on the discharge side of the hair catcher. The gauge aids in detecting any loss of head. Normally, there are valves on each side of the hair catcher. With both of the valves closed, changing the buckets on this component is a quick and simple job. The sand, gravel bed, bottom, outside shell and piping of the pressure sand filter should be inspected. The elements, inside shell, outside shell and pipes should be inspected on the pressure type diatomaceous earth filter. The vacuum type diatomaceous earth filter is the easiest type of filter to maintain. With the open tank, the elements can be seen and worked on very easy. Rate of flow controllers should be checked for leaks, freedom of movement,and cleanliness. The controller should be disassembled and inspected. Pressure gauges should be removed and tested for accuracy.

Read AFR 91-26, Chapter 10, pgs 245 thru 256.

SUMMARY

Swimming is one form of exercise that Air Force personnel and their families use for recreational purposes. To be usable the pool water must be free of diseases. For a pool to operate properly and have a good quality of water, competent operators are needed.

Circulating pools are mainly used by the Air Force. There are three types of circulating pools; overflow trough, deck level and wading. The water used in these pools must be approved by the base medical personnel.

The water leaves the pool and first goes through a hair catcher which removes hair, lint, and other large bits of foreign matter. Next the water is pumped into the filter. The water is filtered every six to eight hours. There are two types filters used at pools: pressure sand and diatomaceous earth. Pressure sand can be either horizontal or vertical. Diatomaceous Earth filters can be either pressure or vacuum. The water flow goes through a rate of flow meter and a rate of flow controller, and it is then chlorinated. The water is evenly distributed by water return inlets.

Tests must be taken to determine if the quality of the pool water is acceptable. Bacterialogical, turbidity, pH, chlorine residual, and temperature tests are taken. The pool operator should enter the results of theses tests on AF Form 708.

All safety precautions must be followed to prevent injury or death. The pool operator must ensure that all of the equipment is working properly. Extra care must be used with chlorine cylinders and chlorinators to prevent chlorine gas from leaking.

AFR 91-26 should be used when the pool operator maintains the pool or any pool component.

EXERCISE III-7-7a

PART 1

INSTRUCTIONS

Use AFR 91-26 and your study guide/workbook to complete the following questions.

1. Who approves the water used at a base pool?

____

2. Who gives the final approval when a base pool is opened?

____

3. What are the three types of circulating pools?

   a. ____

   b. ____

   c. ____

4. What is the difference between an overflow trough and deck level type pool?

____

____

5. What type pool is most often used by the Air Force?

____

6. List the types of filters used at pools.

   a. ____

   b. ____

   c. ____

7. What two types of filters does the AF use at base pools?

____

____

8. Who performs the bacteriological test? ____________________

____

9. How often is the bacteriological test? ____________________

____

10. List the chemicals used in the operation of a swimming pool. ____________________

____

____

11. What is used to determine if turbidity is present in the pool water? __________

____

____

12. At what range is the pH maintained for safe pool water? ____________________

13. What affect will a high alkalinity level in pool water have on bathers?

____

____

14. Where and how often are samples taken for the pH test? ____________________

____

15. At what ppm must the chlorine residual be maintained for safe pool water?

____

16. Where and how often are the samples taken for the chlorine residual test?

____

17. What affect will a high acid content in pool water have on bathers?

____

____

18. What is the number and title of the form used to record the pH, chlorine, residual, temperature and other readings? ____________________

19. How is scum removed from the pool water? ____________________

____

20. How is floating debris removed from the pool water? ____________________

____

21. What manual should be consulted when maintaining swimming pool equipment?

____

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PART 2

INSTRUCTIONS

Select the correct term with the incomplete statement pertaining to swimming pools.

1. Bacteriological tests ____________.
2. Chlorine residual ______________.
3. pH test ______________________.
4. Aluminum sulfate ______________.
5. Turbidity test ________________.
6. Hair catcher __________________.
7. Sodium carbonate ______________.
8. Solium hypochlorite ____________.

a. Use as a coagulant.

b. Determined by a 6" black disc.

c. Used to adjust pH.

d. Used as a disinfectant.

e. Taken twice a week by the Environmental Health section.

f. Taken from corners of pool every hour and recorded every 3 hours.

g. Taken from ends of pool every 3 hours and recorded.

h. Located on the suction side of the pump to remove hair and other foreign matter.

PART 3

INSTRUCTIONS

Using AFR 91-26 and your notes, answer the following questions concerning swimming pools.

1. What is the purpose of the hair catcher? ________________________________

____

____

2. Explain the purpose of the water return inlets. ___________________________

____

____

3. List the daily operational procedures a swimming pool operator performs at a swimming pool.

   a. ____

   ____

   b. ____

   ____

   c. ____

   ____

   d. ____

   ____

e. ____

____

f. ____

____

g. ____

____

4. List the purpose of gauges, meters and rate controllers. ______________

____

____

____

5. List the two main types and the functions of filters used at swimming pools.

Type of Filter	Function
a.	
1	
2	
b.	
1	
2	

6. What operating procedures are taken when a base swimming pool is opened for the season?

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

h. ____

i. ____

7. What steps are taken for the shut down of the pool for the season?

a. ____

b. ____

c. ____

EXERCISE III-6-6b

INFORMATION

During the field trip to the base swimming pools, view the field water purification unit (ERDLATOR). While the unit is uncovered, identify the components of the unit. Your instructor will give you progress check III-6-6b. This will then complete your objective.

EXERCISE III-6-6e

During the field trip to the base swimming pool and training area, view the field water purification unit (ROWPU). While the unit is uncovered, identify the components of the unit. Your instructor will give you progress check III-6-6d. This will complete your objective.

EXERCISE III-7-7b

PART 1

This is an objective exercise that will be completed during the field trip to the base swimming pool and training area. During the field trip complete the pool diagram. The instructor will issue the diagram and will confirm your answers.

PART 2

This is an objective exercise that will be completed during the field trip to the swimming pool trainer and training area. The instructor will issue the diagram to you and confirm your answers.

REFERENCES

AFR 91-26, Maintenance and Operation of Water Supply, Treatment and Distribution Systems
TO 40W4-9-1, Field Water Purification Unit 600 GPH
TM 5-4610-215-10, Operator's Manual, Water Purification Unit, Reverse Osmosis, 600 GPH
TM 5-700, Field Water Supply

PROGRESS CHECK
J3ABR56631 000-III-1 thru 7

Technical Training

Environmental Support Specialist

WATER SUPPLIES AND TREATMENT

June 1986

3700 TECHNICAL TRAINING WING
3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

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7	Swimming Pools	7-1

ACKNOWLEDGEMENT

PREPARATION of Unit 5 of this PC was aided through the cooperation and courtesy of Ionics Incorporated, Watertown, Ma. This company furnished the information concerning Electrodialysis Demineralization. Permission to use their publication, AQUAMITE 1, Operating and Maintenance Manual, Serial Number 527, is greatfully acknowledged. In accordance with the copyright agreement, distribution of this PC is limited to DOD personnel.

Supersedes WB 3ABR56631-III-1 thru 7, June 1985

654

3770 Technical Training Group
Sheppard Air Force Base, Texas

PC J3ABR56631 000-III-1

WATER WELL OPERATION AND MAINTENANCE

OBJECTIVES

Given incomplete statements about ground water and water wells, complete each statement by making written responses. Four of the six responses must be correct.

Using data pertaining to wells, define terms and calculate static, pumping, and drawdown levels with a maximum of one instructor assist.

PROGRESS CHECK III-1-1a

INSTRUCTIONS: Complete the following incomplete statements by filling in the blanks. Four of the six must be correct.

1. Two types of aquifers are the ______________ and the ______________.

2. The most reliable method of establishing that ground water is present is by finding ______________ ______________.

3. Two methods of constructing a well are the ______________________________, and the ______________________________.

4. Backwashing or surging a well is done because the ______________ is plugged up.

5. List two of three methods used for cleaning well screens.

   ____

   ____

6. The recommended dosage of chlorine for superchlorination of a well is ____________ ppm.

-----STOP-----

Before proceeding any further have the instructor check your work.

____________ Instr Initials

COURSE J3ABR56631 000

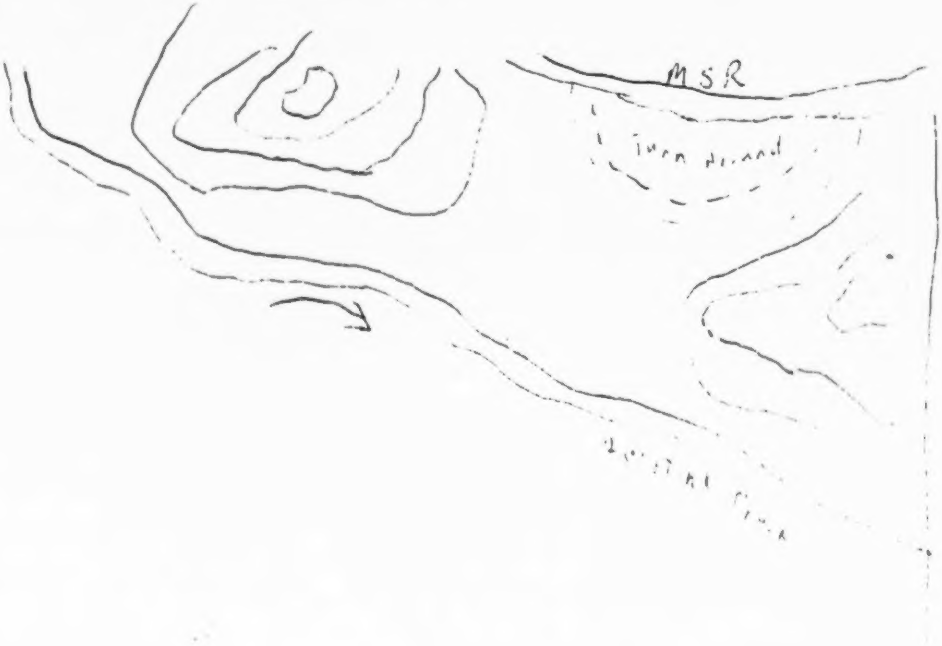
7 Aug 86

ERRATA SHEET
FOR
PROGRESS CHECK J3ABR56631 000 III

PAGE	ACTION
6-3	Replace with attached pg 6-3
6-5	Replace with attached pg 6-5
6-11	Replace with attached pg 6-11

PROGRESS CHECK III-6-a

INSTRUCTIONS: Given site selection criteria, your notes, and TM 5-700, select the correct site to position the WPU. Place the number in the selected area of your best choice. Three of the four must be correct.



1 RAW WATER PUMP

2 600 GPH WATER PURIFICATION UNIT

3 CLEAR WELL (STORAGE TANKS)

4 DISTRIBUTION PUMP WITH NOZZLES

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

______Instr initials

PROGRESS CHECK III-6-b

INSTRUCTIONS: Using the drawing of the (ERDLATOR) field water purification tank (figure 6-1) with numbered items and a list of components, match the components to the numbered items. Ten of twelve components must be correct.

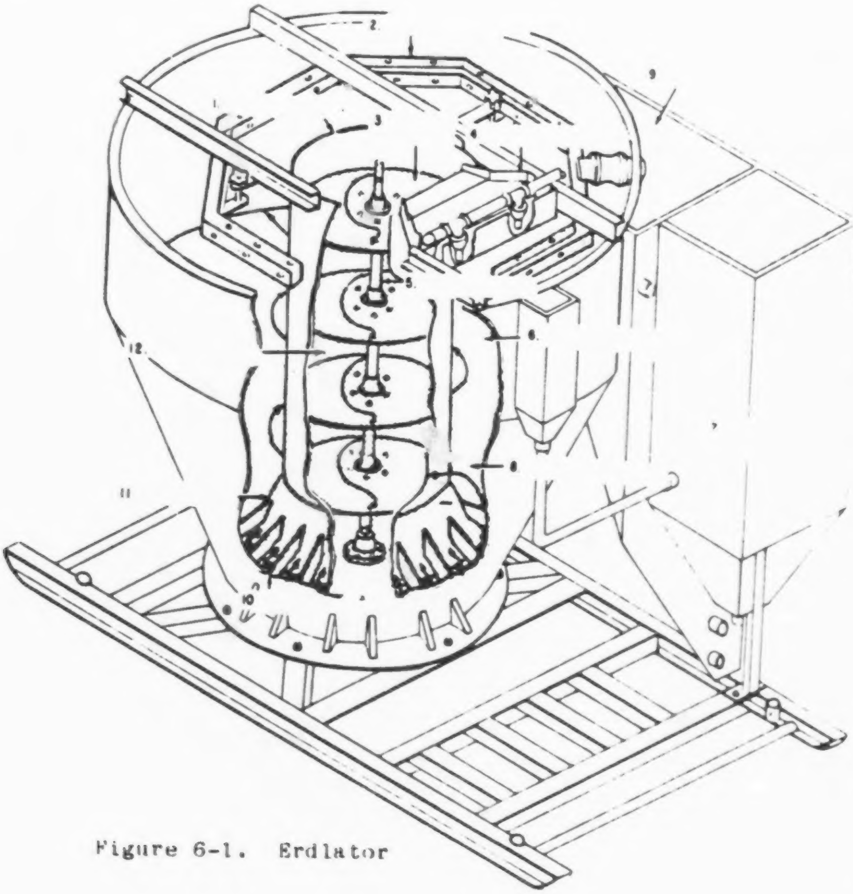


Figure 6-1. Erdlator

Components

a. Downcomer tube

b. Baffle rings

c. Circular discs

d. Influent launder

e. Agitator shaft

f. Separator zone

g. Sludge concentrator tank

h. Effluent launder

i. Baffle

j. Wet well

k. Mixing zone

l. Clarification zone

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

______Instr initials

PROGRESS CHECK III-6-e

INSTRUCTIONS: Match the numbered areas on the RO unit to the list of components. Seven of 11 must be correct. TO 40W4-13-1 may be used. All items will be used only once.

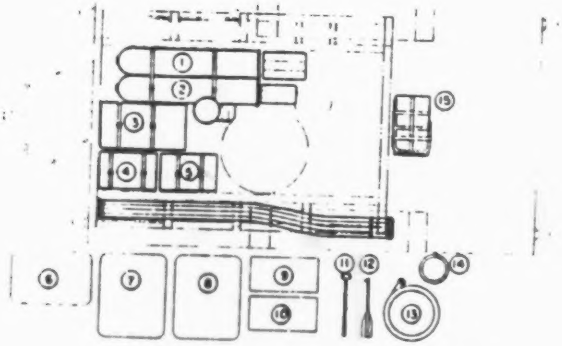


Figure 6-3. RO Unit

Components:

a. Distribution pump ________________

b. Paddles ________________

c. NBC tanks ____________

d. Folded product water tanks __________

e. Sledge hammer ________________

f. Raw water pump ________________

g. Utility pail _______________

h. Backwash pump _______________

i. Storage boxes _______________

j. Brine tank _______________

k. Rubber hose _______________

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

______Instr initials

PROGRESS CHECK III-1-b

PART 1

INSTRUCTIONS: Identify the following definitions using the correct term.

1. The level of ground water in a well before pumping is _______________.

2. This is the maximum number of gallons per minute that can be pumped from the well over a six-hour period during which the pumping rate is maintained.

   ____

3. This is the rate of pumping that produces a drawdown of 50 percent of the drawdown obtained when the well was built and pumped at maximum yield.

   ____

4. The total length of the air line is also called the ____________________________.

PART 2

INSTRUCTIONS: Using the following information calculate the static level, pumping level and drawdown of wells.

1. Calculate the static level if the length of the air line is 700 ft and the psi before pumping is 10.

2. PSI while pumping is 7, calculate the pumping level.

3. Calculate drawdown when the psi before pumping is 25 and the psi while pumping is 5.

-----STOP-----

Before proceeding any further have the instructor check your work.

____________ Instr Initials

WATER TREATMENT PROCESSES

OBJECTIVES

Given information related to water clarification, match statements identifying the facts and terms which pertain to water clarification. Six of the nine must be correct.

Using information about water softening, identify facts and terms by completing ten statements. Seven of ten must be correct.

Given information related to removal of taste, odor, and color, list the methods used to remove taste, odor, and color in water supplies. Five of the seven must be correct.

Given information related to water treatment processes, match fact and terms related to stabilization, disinfection, fluoridation and defluoridation. Six of ten must be correct.

PROGRESS CHECK III-2-a

INSTRUCTIONS: Match the terms in Column B to the statements and facts in Column A. Some terms may be used once, twice, or not at all.

COLUMN A

_____ 1. Process of becoming clear.

_____ 2. Process of clarification occurring at the reservoir.

_____ 3. The reaction of a coagulant in water that causes it to clot, curdle, or congeal into a mass or group.

_____ 4. Two substances that must be in water for coagulation and flocculation to occur.

_____ 5. Temperature, pH, turbidity, chemical composition of water, degree of agitation.

_____ 6. Procedure used to determine the correct dosage for coagulation-flocculation.

_____ 7. Process used to remove settleable solids.

_____ 8. Process used to remove suspended materials. It is also the fastest way to clarify water.

_____ 9. To cause to separate from solution or suspension, to fall or come suddenly out of solution.

COLUMN B

a. Adsorption

b. Jar test

c. Plain sedimentation

d. Precipitate

e. Sedimentation

f. Filtration

g. Coagulant and alkalinity

h. Factors affecting coagulation-flocculation

i. Coagulation

j. Clarification

-----STOP-----

Before proceeding any further have the instructor check your work.

_____________ Instr Initials

PROGRESS CHECKLIST III-2-b

INSTRUCTIONS: Complete the following statements. Seven of ten questions must be correct.

1. The removal of Ca and Mg compounds that cause hardness in water is called ______________________________.

2. Temporary hardness is called ______________ hardness and permanent hardness is called ____________ hardness.

3. Temporary hardness is caused by what four compounds.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

4. Permanent hardness is formed by Ca and Mg combining with ____________ and ____________.

5. Two methods commonly used to remove hardness from water are ____________ and ____________.

6. Which method of softening completely removes hardness from water?

   ____

7. Two chemical tests that can be run to determine carbonate and noncarbonate hardness are the ____________ and ____________ tests.

8. Two chemicals used in the removal of temporary and permanent hardness are ____________ and ____________.

9. The chemical used to remove temporary hardness is ____________.

10. The chemicals used to remove permanent hardness are ____________ and ________________.

-----STOP-----

Before proceeding any further have the instructor check your work.

__________ Instr Initials

PROGRESS CHECK III-2-c

INSTRUCTIONS: List the methods used to remove taste, odor and color.

1. List three ways to control taste and odor.

   a. ____________________

   b. ____________________

   c. ____________________

2. List four methods to control color.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

-----STOP-----

Before proceeding any further have the instructor check your work.

____________ Instr Initials

PROGRESS CHECKLIST III-2-d

INSTRUCTIONS: Match the terms in Column B with the facts in Column A. Six of ten must be correct. Some terms may be used once, twice or not at all.

COLUMN A

_____ 1. The adjustment of pH and alkalinity of a water to a calcium carbonate saturation equilibrium value.

_____ 2. Two methods of stabilizing lime softened water.

_____ 3. Used to kill pathogenic bacteria.

_____ 4. The forms of chlorine used to disinfect water are Cl_2, ClO_2, $Ca(OCl)_2$ and _______________.

_____ 5. Is the term which is applied to the available chlorine which remains after the chlorine demand has been satisfied.

_____ 6. The chlorine present in water which reacts with ammonia or nitrogen to form chloramines.

_____ 7. One of three methods of chlorination that produces a residual of free available chlorine, with no combined chlorine present.

_____ 8. Three forms of fluorides used to fluoridate water are NaF, Na_2SiF_6 and _____________.

_____ 9. Desired amount of fluoride in water.

_____ 10. Three chemicals used to defluoridate are activated alumina, bonechar and ________.

COLUMN B

a. Residual chlorine

b. H_2SiF_6

c. 1.0 ppm

d. Recarbonation

e. NaOCl

f. Marginal chlorination

g. Stabilization

h. Combined chlorine

i. Magnesium compounds

j. Break-point chlorination

k. Chlorine

l. Hexameta phosphates

m. HF(OCl)

-----STOP-----

Before proceeding any further have the instructor check your work.

_____________ Instr Initials

MONITOR/OPERATE AND MAINTAIN WATER TREATMENT PLANT EQUIPMENT

OBJECTIVES

Given statements about chemical mixing tanks, identify as true or false the statements concerning the monitoring and operation of chemical mixing tanks. Three of the four must be correct.

During a field trip to the local municipal water treatment plants, monitor the operation of plant components by making a written response IAW a checklist. No more than three instructor assists are allowed.

Using information and the water plant trainer, work as a team to monitor/operate the trainer, with no more than three instructor assists.

Using information and the water plant trainer and equipment and working as a team, perform the required maintenance on the trainer and equipment. Four of six maintenance problems must be performed correctly.

Using AFR 91-26, complete statements concerning the purpose, and types of aerators. Five of seven must be correct.

Using AFR 91-26, match the maintenance procedures used for each type aerator. Three of five must be correct.

PROGRESS CHECK III-3a

INSTRUCTIONS: Identify the following statements concerning the monitoring and operation of chemical mixing tanks as being true or false. Three of the four must be correct.

_____1. The dissolving tank is often an integral part of the feeder assembly.

_____2. Chemicals drawn in solution form from a mixing tank are usually fed at a rate of 200-300 gal/per hour.

_____3. To eliminate the possibility of an explosion, mixing tanks should never be covered.

_____4. Chemicals that are completely soluable in water require continuous mixing in the feed tank.

-----STOP-----

Before proceeding any further, have the instructor check your work.

___________ Instr Initials

PROGRESS CHECK III-3-b

EXERCISE 3a

INSTRUCTIONS: Answer the following questions or complete the statements by filling in the blanks. Three instructor assists are authorized.

1. Plain sedimentation and aeration.

   a. What is the purpose of the secondary reservoir?

   b. How is oxygen added to the water?

   c. Is water entering the reservoir?

   d. ______________ and ______________ can be added to the water to control algae.

   e. What type of pump is used to carry the water to the plant?

   f. Is the water in the reservoir entering the overflow?

   g. Do you see algae growing?

2. Plant chemical mixing storage areas.

   a. What fluoride compound is used?

   b. Why is the fluoride tank outside?

   ____

   ____

   c. What two chemicals are stored in the silos?

   ____

   ____

   d. List two safety items on silos?

   ____

   ____

   e. The effluent line of the ammonia tank is color coded ______________________.

   f. Why is the ammonia tank outside? ______________________________

3. Recovery well and lagoons.

   a. From where is the water into the recovery well pumped? ______________

   b. Is water entering the recovery well? ______________________

   c. Is there enough room in the recovery well for emergency backwash?

   d. List two safety items on the recovery well.

      ____

      ____

   e. What item of safety is missing at the recovery well?

      ____

   f. How many lagoons are there?

   g. Are both lagoons used at the same time?

   h. Is the lagoon floor supposed to be leveled?

   i. Is the water clarifying the closer it gets to the valves? Explain.

   j. What type of isolation valves do they use?

4. Plant basement.

   a. The first chemical added to the raw water line coming into the plant is

      ____.

   b. Another water line joining the raw water supply before it goes into the parshal flume comes from the ______________.

   c. What does the air compressor do?

   d. Are the shafts to the slow mixing paddler for the flocculator in operation?

   e. How is the lime taken to the silos and to the plant?

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5. Laboratory.

   a. Looking at the equipment present in the lab, list the two methods used for water testing.

   b. List five test performed in the lab.

   __________, ______________, ______________, _________________, ____________

   c. List three types of glassware items in the lab.

   ______________, ______________, ______________

   d. Why is the water running in the lab?

   e. How often are the tests run in the lab?

   f. Safety - what safety precautions are followed in the lab?

6. Water control panel.

   a. What is the volume of water coming into the plant. (Read Parshall Flume #1 and Parshall Flume #2 and add them together.)

   b. What is the discharge pressure on the line? (Read Discharge Pressure Meter).

   c. How much water is leaving the plant? (Read Discharge Flow #1 and Discharge Flow #2 Meters, and add them together.)

   d. How many feet of water are there at the reservoir? (Read Reservoir Level Gauge.)

7. Pump panel.

   a. How many pumps are used for raw water?

   b. How many pumps are used for treated water?

   c. How do you know if the pumps are working?

8. There are three main groups of chemical feeders; gas, solution, and dry. Complete the following exercise.

a. A "V" notch chlorinator is used to feed chlorine ______________________.

b. Record lbs/day of chlorine being fed as prechlorination. ______________

____

c. Record lbs/day of chlorine being fed as post chlorination. ______________

____

d. What is the total lbs/day chlorine being fed? ______________________

e. How many one-ton cylinders are connected? ________________________

f. How many cylinders are being used? ______________________________

g. Is the exhaust system for chlorine feed room free of obstructions? ________

h. Is fluoride being fed into the water? Yes ____ No ____

i. What type of fluoride chemical feeder do they use? __________________

j. What is used to stabilize the water? ______________________________

k. Where is the stabilization done in relation to filtration? ____________

l. Is lime, CaO, being fed into the slurry mixer? ______________________

m. $CaO + H_2O$ will yield ______________, commonly called ______________.

n. Why is lime solution fed in open channels? ________________________

____

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9. Parshall Flume, flocculator settling tanks and filter.

a. What chemicals are added at the parshall flume?

______________, ______________, ______________, ______________, ___________

b. List two things that happen at the parshall flume.

____

____

c. What is the purpose of the flocculator?

d. What is a good size of floc?

e. What stirs the water in the flocculator?

f. What is the purpose of the baffles?

g. List two of three reasons why floc would settle out in the flocculator.

h. What is the purpose of the settling tank?

i. Rectangular settling tanks have ______________ for sludge removal and round settling tanks have ______________.

j. Where does the sludge and water go when it is removed from the settling tank?

k. List three chemicals that are added at the trough between the secondary settling tank and the filters.

l. What type of sand filters does this plant have?

m. How often are the filters backwashed?

n. Do these filters use surface washing? YES_______ NO ______

o. Do all filters have surface wash?

p. What is the present head loss on filter #2?

q. How many filters are posted on the gauge panels?

r. What kind of valves does this plant use on the filters?

s. Where does the backwash water go to after backwashing the filters?

t. What is the tank called where the treated water is held, before it goes to distribution system or storage tank?

u. What type of storage tanks does this plant have?

v. What type of pumps do they use to move water?

w. What safety precautions should be taken when working around an open tank? Name two of three.

10. Upflow Clarifier

a. Where are the chemicals added to the upflow clarifier?

b. What collects the coagulated water?

c. How is the sludge removed?

d. Where does the coagulated water go after treatment?

-----STOP-----

Before proceeding any further have the instructor check your work.

____________ Instr Initials

PROGRESS CHECKLIST III-3-c

EXERCISE 3b

INSTRUCTIONS: Using the following operating procedures and guidelines, start, operate, backwash and shut down the water trainer with no more than three instructor assists.

OPERATING PROCEDURES

1. Close drain valves on raw water tank (2), chemical mixing tanks, (5) (6), flocculator (7), settling tank (8) and filter (9).

2. Check equipment for security and remove any objects or materials which may cause improper operation.

3. Open inlet valves to raw water tank (1), and on elevated storage tank (17).

4. Place all electrical switches in OFF position. Turn the master switch on wall and master switch on trainer control panel ON.

5. When raw water tank is 1/2 full, turn low lift pump on. Open #3, prime the pump, open #4 turn pump on, open #5.

6. Prepare chemical solutions (prepare additional amounts as needed during operation.)

   a. Ferric Chloride preparation

      (1) To red colored 3 gallon container, add one gallon of water.

      (2) CAREFULLY!!! Add contents of one package of Ferric Chloride powder slowly and stir with wooden stirrer until powder is dissolved completely.

      (3) Add 2 more gallons of water and stir well.

   b. Aluminum Sulfate preparation

      (1) To white colored 3 gallon container, add one gallon of water.

      (2) Measure 1000 ml of Aluminum Sulfate powder and add to the one gallon of water. Stir mixture with wooden stirrer until dissolved.

      (3) Add 2 more gallons of water and stir well.

7. Fill slurry feeder with water to just under the overflow line.

   a. Add 1000 ml of lime powder.

   b. Turn mixer on (switch on control panel).

   c. Recharge every 30 minutes.

8. Set each solution feeder as follows:

   a. Check oil - must show 1/2 full in sight gauge.

   b. Place suction line in solution.

   c. Place adjustment lock in unlock postion.

   d. Turn feeder switch ON.

   e. Unlock adjustment and adjust to 50% stroke and lock.

   NOTE: Whenever adjusting stroke, the locking level should be in unlock position and the feeder must be running. When feeding or measuring feed rate, it must be in lock.

   f. Adjust feeder to 20 ml per minute. (Turn dial on feeder to 20.)

9. When flocculator tank gets 1/2 full, turn it on (switch on control panel.)

10. Fill the sand filter as follows:

    a. Close influent valve to filter (9).

    b. Open gullet drain line valve (10).

    c. Open effluent valve from filter to recovery well valve (11).

    d. Open backwash valve (12) until the capacity of the gullet drain is reached.

    e. When water is clear, close gullet drain line valve (10).

    f. When filter fills to the even level, close backwash valve (12), open filter influent valve (9), and turn on high lift pump.

11. Before the settling tank is full, set up hypochlorinator as follows:

    a. Calcium Hypochlorite Solution (HTH)

        (1) To a one gallon plastic container, add one measuring spoon of HTH.

        (2) Fill plastic container to 2" below the top with clear water.

        CAUTION: When handling HTH, do not spill or breathe dust.

        (3) Insert suction tube into HTH solution. Plug hypochlorinator in.

        (4) Prime hypochlorinator. Turn dial to 10 GPD rate.

        (5) When discharge line is full, turn hypochlorinator off.

        (6) Place discharge line tip inside the settling tank effluent baffle.

        (7) When the settling tank is full and water has entered into the baffle of the settling tank, START HYPOCHLORINATOR.

        (8) Set the rate of 5 GPD.

        (9) When water enters the storage tank, take a sample from valve ( ) and test for chlorine residual. NOTE: A good chlorine residual reading for this trainer is anything from a trce to 0.2 ppm.

12. a. If over chlorinating, cut down on the rate. Take a chlorine residual test after 10 minutes. Continue doing this until you reach the desired Cl residual.

    b. If under-chlorinating increase the rate and take a reading after 10 minutes. Continue doing this until you reach the desired Cl residual.

13. Shutdown

    a. Turn water off, valve (1).

    b. Turn off low lift pump.

    c. Open raw water drain valve (2).

    d. Stop sludge rakes and open drain lines to settling tank valve (8) and flocculator valve (7).

    e. Turn off flocculator (control panel).

    f. Fill solution buckets with clear water and purge solution feeders.

    g. Drain rapid mix and slurry tanks.

h. Flush all tanks with clear water (use hose).

i. Turn off solution feeders and slurry feeder.

j. Be sure the filter is left full of clear water by backwashing.

14. Backwash filter as needed.

a. Close valve (9). Influent valve to filter.

b. Open valve (11) to recovery well.

c. Open backwash valve (12) slowly to 2 gal/min. When bed is filled, increase backwash rate to 15 gal/min.

d. Probe filter for hard spots.

e. After backwash is completed, turn backwash valve (12) off.

f. Close recovery well valve (11), open influent valve (9) to filter.

g. Filter is now in operation.

PROGRESS CHECK III-3d

INSTRUCTIONS: Attached are three Maintenance Action Sheets (AF Form 1841). These forms are used under actual field conditions to authorize the inspections and correction of minor maintenance deficiencies in installed equipment. Your instructor has created a total of five maintenance discrepancies in the water trainer. Using the AF Form 1841 as a guide, inspect each component and correct any maintenance discrepancy which may exist. No more than two of the two maintenance problems may be missed. List the maintenance problem and the corrective action taken.

MAINTENANCE PROBLEM	CORRECTIVE ACTION
1.	
2.	
3.	
4.	
5.	

-----STOP-----

Before proceeding any further have your instructor check your work.

___________Instr Initials

MAINTENANCE ACTION SHEET	COST CENTER 491 W/W	DESCRIPTION Water Plant Trainer	MAS NUMBER 012

REQUIRED MAINTENANCE ACTIONS	REFERENCE	STANDARD HOURS	FREQ.	CREW SIZE	HEAVY EQP
SETTLING TANK	AFR 91-26	.25	W	2	1
Inspect chain and spocket on flights					
Inspect Valve					
Inspect inlet baffle					
Inspect Wiers					
Inspect for corrosion					
RAPID SAND FILTER	AFR 91-26	.25	W	2	1
Inspect for uniformity of sand layers					
Inspect valves					
Inspect for corrosion					
Inspect float					
WET WELL	AFR 91-26	.25	W	2	1
Inspect float					
Inspect electrical connection					
Inspect transfer pump					
Inspect for corrosion					

DATE 1 May 86	WCF INITIALS	DATE 1 May 86	SUPERINTENDENTS INITIALS

AF FORM JUL 72 1841

MAINTENANCE ACTION SHEET	COST CENTER 491 W/W	DESCRIPTION Water Plant Trainer	MAS NUMBER 012

REQUIRED MAINTENANCE ACTIONS	REFERENCE	STANDARD HOURS	FREQ.	CREW SIZE	HEAVY EQP
CHEMICAL MIXING TANK	AFR 91-26	.25	W	2	1
Inspect float					
Inspect motor					
Inspect for corrosion					
Inspect for leaks					
FAST MIX	AFR 91-26	.25	W	2	1
Inspect valves					
Inspect motor, belts, and speed reducer					
Inspect stirrer					
Inspect for corrosion					
SLOW MIX	AFR 91-26	25	W	2	1
Inspect motor, belts, and speed reducer					
Inspect bearing supports					
Inspect wooden paddles					
Inspect valves					
Inspect for corrosion					

DATE 1 May 86	WCF INITIALS	DATE 1 May 86	SUPERINTENDENT'S INITIALS

AF FORM JUL 73 1841

MAINTENANCE ACTION SHEET	COST CENTER 491 W/W	DESCRIPTION Water Plant Trainer	MAS NUMBER 012

REQUIRED MAINTENANCE ACTIONS	REFERENCE	STANDARD HOURS	FREQ.	CREW SIZE	HEAVY EQP
ELEVATED STORAGE TANK	AFR 91-26	.25	W	2	1
Inspect structural supports					
Inspect valves					
Inspect tank for leaks					
Inspect for corrosion					

DATE 1 May 86	WCF INITIALS	DATE 1 May 86	SUPERINTENDENTS INITIALS

AF FORM JUL 72 1841

PROGRESS CHECKLIST III-3-e

INSTRUCTIONS: Using AFR 91-26, complete the following statements concerning aerators. Five of seven must be correct.

1. Aerators remove ______________ gases from the water.

2. Two gases that are removed by aeration are ______________ and ______________.

3. Four types of aerators are ______________, ______________, ______________, and ______________.

4. The type of aerator found at the reservoir is the ______________ type.

5. Bubbling air below the water surface as in a fish tank is an example of a ______________ type aerator.

6. The type of aerator that uses coke on the tray to remove taste and odor is the ______________ type aerator.

7. A waterfall type aerator is called a/an ______________.

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

______Instr initials

PROGRESS CHECKLIST III-3-f

EXERCISE 3f

INSTRUCTIONS: Using AFR 91-26 and your notes, match Column A Maintenance to Column B Aerators. A minimum of 3 out of five must be correct. Some answers may be used once, twice or not at all.

COLUMN A. MAINTENANCE

_____ 1. Increase compressor or blower pressure to supply a given quantity of air when aerator is clogged.

_____ 2. Clean or replace coke tray if algae growth is present or deterioration of coke is present.

_____ 3. Cleaning by scrubbing or using copper sulfate and/or chlorine solution to control algae growth is recommended for this aerator.

_____ 4. Clean out sediment and dirt as required, examine joints for leaks.

_____ 5. Make necessary repairs to screens and enclosures.

COLUMN B. AERATORS

a. Cascade or Step

b. Spray Nozzle

c. Tray and Splash Pan

d. Diffuser

e. Venturi Type Aerator

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

_______Instr initials

3770 Technical Training Group
Sheppard Air Force Base, Texas

PC J3ABR56631 000-III-4

MONITOR/OPERATE AND MAINTAIN ION EXCHANGER (DEMINERALIZATION) UNIT

OBJECTIVES

Given terms and statements pertaining to an ion exchange unit, match the terms to the statements. Twelve of seventeen must be correct.

Given information, ion exchange softener and demineralizer units, work as a team to monitor/operate the ion exchange units with no more than four instructor assists.

Given information and an ion exchange trainer work as a team to maintain the unit with no more than one instructor assist.

PROGRESS CHECK III-4-a

INSTRUCTIONS: Match Column A (terms) to Column B (statements) pertaining to ion exchange (demineralization) units. Some answers may be used once, more than once, or not at all.

COLUMN A. TERMS

_____ 1. Purpose of ion exchange

_____ 2. Theory of ion exchange

_____ 3. Sodium zeolite

_____ 4. Synthetic resins

_____ 5. Anion exchanger

_____ 6. Weak base anion

_____ 7. Strong base anion

_____ 8. Cation exchanger

_____ 9. Chemical injection

_____ 10. Mixed bed demineralizer

_____ 11. Dual bed demineralizer

_____ 12. Natural resins

_____ 13. Regenerant tank

_____ 14. Underdrain

_____ 15. Multiport valve

_____ 16. Backwash

_____ 17. Hydrogen zeolite

COLUMN B. STATEMENTS

a. Type of ion exchanger used at base laundries.

b. Used to remove or reduce TDS.

c. Green sand used as a zeolite.

d. Makes water acidic and often used along with a strongly basic ion exchanger.

e. Second step in ion exchange regeneration.

f. Removes silica.

g. Evenly distributes backwash water.

h. Resin is positively charged.

i. Anion and cation resins in same tank.

j. Is longer lasting and has higher exchange capacity.

k. A reversible chemical reaction between ions in solution and ions attached to a solid material.

l. Removes only strong acids.

m. Uses sulfonated polystyrene as a zeolite.

n. Resins are housed in two separate tanks.

o. Holds chemicals.

p. Directs flow of water during cycles of operation.

q. First step in regeneration.

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

______Instr initials

PROGRESS CHECK III-4-b

PART 1

SODIUM CATION EXCHANGE OPERATION PROCEDURES

INSTRUCTIONS: As a member of a team, monitor and operate the sodium cation exchange unit using the following step-by-step procedures. The instructor may assist no more than four times throughout the operation of the unit. Units may be assumed to be exhausted and regeneration done without actual use of chemicals at instructor's discretion. Times taken to perform those steps may be adjusted accordingly.

1. Service

   a. Place the unit into service as follows:

      (1) Place solo valve in service position #3.

      (2) Open valve #2.

      (3) Open valve #1, the hardwater inlet valve, and adjust to a maximum flow of GPM.

   b. Perform test(s) for exhaustion. If bed is exhausted, regenerate unit.

2. Preparing Regenerant Solution

   NOTE: This step can be omitted if the regenerant (brine) tank contains four or more inches of brine solution. Furthermore, there should be undissolved salt in the bottom of the tank. If the solution level in the tank is less than four inches proceed to step a under close supervision of the instructor.

   a. For each four inches the brine level is below its upper level in the tank, add 15 pounds of salt to the brine tank. For example, if the brine is eight inches low, add 30 pounds of salt.

   b. Place solo valve in service position No. 3. Valve No. 1 should be open.

   c. Open valve No. 4 and add water up to the "upper brine level" then close.

3. Regenerating Sodium Zeolite Unit

   a. Backwash (Step No. 1)

      (1) Close valves No. (1) and No. (2)

      (2) Open valve No. 3 momentarily to release pressure in tank and then close.

      (3) Place solo valve on BACKWASH, position No. 1.

      (4) Control influent by valve No. (1) at 2 GPM for 10 minutes, then close.

   b. Regeneration (Step No. 2)

      (1) Adjust solo valve for regeneration and slow rinse in position No. 2.

      (2) Open valve No. 1. Flow rate is controlled by the solo valve.

      (3) Open valve No. 4 to permit addition of salt brine to water going through the resin column. Total brine drawdown is four inches and usual time is about 16 minutes.

      (4) Close valve No. 4 when regeneration is completed.

   c. Slow Rinse (Step No. 3)

      (1) When valve No. 4 is closed, the slow rinse begins. Continue slow rinse for 30 minutes.

(2) Close valve No. 1 after the 30 minutes.

d. Final Rinse (Step No. 4)

(1) Place solo valve in service position No. 3.

(2) Fully open valve No. 3.

(3) Open valve No. 1 to give a flow of 2 GPM.

(4) Rinse until salt cannot be tasted in effluent and then close valve No. 3.

e. Service Run (Step No. 5)

(1) Open valve No. 2 on service line.

(2) To adjust to the desired maximum flow:

(a) Open valve No. 3.

(b) Using valve No. 1, adjust the desired maximum flow of 6 GPM.

(c) Then close valve No. 3. This places the ion exchanger back in service.

PART 2

DUAL BED DEMINERALIZER OPERATING PROCEDURES

INSTRUCTIONS: As a member of a team, monitor and operate the dual bed demineralizer using the following step-by-step procedures. The instructor may assist no more than four times throughout the operation of the unit. Unit may be assumned to be exhausted and regeneration done without actual use of chemicals at instructor's discretion. Times taken to perform those steps may be adjust accordingly.

STEP 1 - SERVICE

a. Solo-valve No. 1 in "Run" position (Position No. 3)

b. Solo-valve No. 2 in "Run" position (Position No. 3)

c. Open valve No. 13 on service line

d. Control flow with valve No. 9 to 1.5 GPM, maximum 2 GPM

e. Perform test for exhaustion. If bed is exhausted, regenerate unit.

STEP 2 - SHUTDOWN (End of service run prior to regeneration)

a. Solo-valve No. 1 in "Run" position (Position 3)

b. Solo-valve No. 2 in "Run" position (Position 3)

c. Close valve No. 9 and No. 13

d. Open valve No. 12

e. Solo-bridge switch to "Off" position

STEP 3 - REGENERATION

a. Backwash

NOTE: Start backwash SLOWLY, increase gradually to prescribed rate. Always have sampling jar under solo-valve drain line; if resin particles are being discharged, reduce rate. Continue backwashing until water is clear and free of suspended matter. Anion column first, cation column second.

(1) Anion Column:

(a) Solo-valve No. 1 in "Run" position (Position No. 3)

(b) Solo-valve No. 2 in "Wash" position (Position No. 1)

(c) Open influent valve No. 9 and backwash at a rate of one (1) gallon per minute for ten (10) minutes (or until effluent is clear).

(d) Close valve No. 9 at end of backwash.

(2) Cation Column:

(a) Solo-valve No. 1 in wash position (Position No. 1)

(b) Solo-valve No. 2 in run position (Position No. 3)

(c) Open influent valve No. 9 and backwash at a rate of two (2) gallons per minute for five (5) minutes (or until effluent is clear).

(d) Close valve No. 9 at end of backwash.

b. Chemical injection and slow rinse

NOTE: Both columns are regenerated and rinsed separately before the final rinse. The anion column should be regenerated each time the cation column is regenerated.

(1) Chemicals Required:

(a) Cation - H_2SO_4 (66°Be) 7.5 lb

(b) Anion - NaOH (flake) 6.0 lb

(2) Preparation of Regenerant Solutions:

NOTE: Omit this step if the solution in the regenerant tanks is four inches or more from the bottom. If the solution is less than four inches proceed to step 1 under close supervision of the instructor.

CAUTION: H_2SO_4 and NaOH are hazardous materials. Face shield, gloves, and apron must be worn when adding these chemicals to water. Add H_2SO_4 and NaOH slowly to water.

(3) Filling Acid Tank (Cation Bed)

(a) Solo-valve No. 1 and solo-valve No. 2 in Run position (position No. 3), all other valves closed.

(b) Open influent valve No. 9. Open valve No. 5, add water until level is 20 inches from top. Close valve No. 9.

(c) Add required amount of acid directly to acid tank and mix.

(d) Open valve No. 9 and add water until level of solution is 2 inches from top of tank, then close valve No. 9.

(4) Filling Caustic Tank (Anion Bed)

(a) Solo-valves No. 1 and 2 in run position (position 3); all other valves closed.

(b) Open valves 6 and 9.

(c) Add required amount of NaOH slowly, stirring constantly.

(d) Fill tank with water until level of solution is 10 1/2 inches from top.

(e) Close valve No. 9.

(5) Chemical Injection and Slow Rinse of Cation Resin

(a) Chemical injection

1 Solo-valve No. 1 in regeneration position (position No. 2).

2 Solo-valve No. 2 in run position (position No. 3).

3 Open and adjust influent valve No. 9 for a flow rate of 0.75 GPM (approximately 30 psi).

4 Open acid valve No. 5.

5 Close acid valve No. 5 when liquid level is 2 inches from bottom of tank (suction time approximately 42 minutes).

(b) Slow Rinse

1 Solo-valve No. 1 in regeneration position (position No. 2).

2 Solo-valve No. 2 in run position (position No. 3).

3 Rinse at 0.75 GPM for 30 minutes (22.5 gal).

4 Close valve No. 9 at end of 30 minutes.

(6) Chemical Injection and Slow Rinse of Anion Resin

(a) Chemical injection

1 Solo-valve No. 1 in run position (position No. 3).

2 Solo-valve No. 2 in regeneration position (position No. 2).

3 Open and adjust influent valve No. 9 for a flow rate of 0.75 GPM (approximately 30 psi).

4 Open caustic valve No. 6.

5 Close caustic valve No. 6 when solution level is 2 inches from bottom of tank. (Suction time approximately 17 minutes.)

(b) Slow Rinse

1 Solo-valve No. 1 in run position (position No. 3).

2 Solo-valve No. 2 in regeneration (position No. 2).

3 Valve No. 12 wide open.

4 Valve No. 9 remains open and controls rinse at 0.75 GPM for 20 minutes (15 gallons).

5 Close valve No. 9 at end of 20 minutes.

c. Final Rinse

(1) Solo-valve No. 1 in run position (position No. 3).

(2) Solo-valve No. 2 in run position (position No. 3).

(3) Valve No. 12 WIDE OPEN.

(4) Set "pointer" of solu-bridge at 50,000 OHM, adjust temperature rheostat at temperature of effluent, turn switch "ON".

(5) Open influent valve No. 9.

(6) Rinse at 2 GPM until GREEN LIGHT burns continuously.

(7) Open valve No. 5 and valve No. 6 for 10 seconds each during rinse to flush out lines.

d. Service Run

(1) Solo-valve No. 1 in run position (position No. 3).

(2) Solo-valve No. 2 in run position (position No. 3).

(3) Open valve No. 13 on service line and close valve No. 12 as soon as valve No. 13 is opened.

(4) Control flow with valve No. 9 to 1.5 GPM, MAXIMUM 2 GPM.

STEP 4 - START-UP AFTER SHUT DOWN

If unit has been shutdown overnight or longer, a short rinse is recommended before proceeding. (Step No. 3, Final Rinse).

STEP 5 - END OF SERVICE RUN

When red light shows continuously, the unit is exhausted. Begin again with Step 2 Shut Down, and repeat above procedure.

MIXED BED DEMINERALIZER OPERATING PROCEDURES

INSTRUCTIONS: As a member of a team, monitor and operate the mixed bed demineralizer.

1. Normal Operation

   a. Open valves E, A, and H.

   b. Check water pressure on the gauge. It should read between 20 and 30 psi.

   c. Check water purity by pressing the ohmmeter button. Any reading above 1 million is good. If below 1 million, regenerate unit.

2. To Shutdown Operation

   a. Close valves H, A, and E.

   b. Close the main ion exchange water supply valve.

   c. Shutdown the cation unit you are using and relieve the pressure in the unit.

3. Regeneration

   NOTE: Omit this step if ohmmeter reads above one million. If ohmmeter reads below one million proceed to step a under close supervision of instructor.

   a. Backwash and Separate

   Close all valves except (B) and (V). These valves should be full open. Open valve (H) until a trickle of water comes out of the drain pipe.

   After five minutes of this slow flow rate observe the resin. If there is a slow movement of the resins in an upward surge, the flow rate is fast enough. However, if there is no apparent movement in the resin bed, increse the flow rate by adjusting valve (H). It is very important that the flow rate is not excessive as it will drive the resin bed completely to the top of the column, thereby causing a plug that will not separate. If this occurs, the resin bed will have to be driven down. This is easily accomplished by closing all valves except (A), (H), and (E). When the plug of resins is driven down, proceed with backwash and separate cycle for 15 minutes.

   b. Regeneration of the Cation and Anion Resin

   Preparing the regeneration solutions - fill a 3-gallon rubber bucket with 2 gallons of softened or demineralized water and stir in 5 pounds of caustic flakes, stirring until thoroughly dissolved. One gallon of 30 percent muriatic acid is used full strength for the cation regenerant.

   CAUTION: Caustic soda and muriatic acid are hazardous materials. Face shield, gloves, and apron must be worn. Add chemicals slowly to water.

   (1) Drawing Up Anion Regenerant

   All valves closed, open valves in this order (C) and (C'). Slowly open valve (H) until the pressure gauge shows 15-20 pounds. Open valve (K) full. This regenerant cycle should take at least 20 minutes to allow contact time with the anion resin. Adjust valve (H) accordingly. Close all valves.

   (2) Rinsing

   All valves closed. Open valves in this order (H), (A), and (K). Continue in this cycle for 20 minutes or until pH of the drain effluent is approximately 8-9. Close all valves.

(3) Regenerating Cation Resin

All valves closed. Place acid draw-up tube in muriatic acid. Open valves in this order: (D'), (D), (K), and (H). Adjust valve (H) so that acid draw-up takes 10-15 minutes. When acid is drawn up, close valves (D') and (D). Open valve (B), readjust valve (H) to slightly increase the flow rate. Rinse cation resin in this position for 10 minutes. Close all valves.

c. Air Mixing of the Resins

(1) To drain water level to approximately 4" above resin bed.

All valves closed. Open valves (V) and (E). When the water level is reached, close (V) and (E).

(2) Open valves (B), (V), and open valve (J) slowly until agitation of the resin bed starts. A mild agitation is all that is necessary. Observe resin for complete mix. This cycle will take approximately 4 minutes. Close all valves.

NOTE: If resin bed appears too dry and not mixing, add water properly by opening valve (H).

d. Final Rinsing

Fill the tank by backwashing rapidly, open valves (V), (B), and (H), to drive the bed down. Close (V), (B) and (H). Open valves in this order: (A), (H), and (E). Turn on conductivity meter. When minimum conductivity is reached, turn on (F) and close (E). Unit is now in service.

Flow control can be adjusted by valve (H) up to 120 gph or wide open.

NOTE: If unit shows preliminary exhaustion, go through the air mixing cycle. This usually adds about 20 percent more to the run cycle.

PROGRESS CHECKLIST III-4-c

INSTRUCTIONS: Using the following and an operator's checklist, indicate the maintenance procedures necessary to correct each condition by writing the maintenance require in the blank space. Five of eight must be correct.

	COMPONENT	CONDITION OF COMPONENT	MAINTENANCE REQUIRED
1.	Tanks	Paint is falling off and pitting on tank surface is present.	
2.	Pipes	Pipes are rattling during operation. Leaks and corrosion are present.	
3.	Valves	Valves are leaking at the stem, and are sticking. Valve handle is broken.	
4.	Multiport Valve	Valve does not turn easily and is chattering during operation.	
5.	Ejector	Insufficient solution going through to the piping.	
6.	Pressure gauges	No pressure or low pressure indication when unit is in operation. Needle appears to be stuck.	
7.	Zeolites	The effluent pressure has dropped below that specified. Organic matter is present in the effluent water.	
8.	Conductivity Meter	Indicator lights are not turning on.	

PROGRESS CHECK III-4-c

INSTRUCTIONS: Attached are two Maintenance Action Sheets (AF Form 1841) which authorize you to inspect and perform minor maintenance on the ion exchange trainer. Your instructor has created three malfunctions to this unit. Using the AF Form 1841 as a guide, inspect each component and correct any maintenance discrepancy which may exist. In order to obtain a satisfactory rating on this progress check, no more than one instructor assist is allowed. List the maintenance problems and the corrective action taken.

	Maintenance Problem	Corrective Action
1.		
2.		
3.		

-----STOP-----

Before proceeding any further, have your instructor check your work.

__________Instr Initials

MAINTENANCE ACTION SHEET	COST CENTER 491 W/W	DESCRIPTION Mixed Bed Demineralizer	MAS NUMBER 025

REQUIRED MAINTENANCE ACTIONS	REFERENCE	STANDARD HOURS	FREQ.	CREW SIZE	HEAVY EQP
CHEMICAL REGENERATE TANKS					
Inspect for corrosion	AFR 91-26	.5	W	2	1
Inspect for leaks					
Inspect piping					
Inspect for sedimentation in bottom of tank					
			Q		
EXCHANGER SHELLS					
Inspect for corrsion	AFR 91-26	.25	W	2	1
Inspect for leaks					
MULTIPORT VALVE					
Inspect for leaks	AFR 91-26	.25	W	2	1
Move valve through all positions					
Inspect for corrosion					
CONDUCTIVITY METER					
Inspect electrical connections	AFR 91-26	/25	W	2	1
Inspect platnium electrodes					
Check for accuracy					
			Q		

DATE 1 May 86	WCE INITIALS	DATE 1 May 86	SUPERINTENDENT'S INITIALS

AF FORM JUL 72 1841

MAINTENANCE ACTION SHEET	COST CENTER 491 W/W	DESCRIPTION Mixed Bed Demineralizer	MAS NUMBER 025

REQUIRED MAINTENANCE ACTIONS	REFERENCE	STANDARD HOURS	FREQ.	CREW SIZE	HEAVY EQP
EXTERNAL COMPONENTS	AFR 91-26	.25	W	2	1
Flow meter					
Inspect for leaks					
Inspect for corrosion					
Pressure gauge					
Inspect for leaks					
Inspect for corrosion					
Valves					
Inspect for leaks					
Inspect for corrosion					
Piping					
Inspect for leaks					
Inspect for corrosion					

DATE	ACF INITIALS	DATE	SUPERINTENDENT'S INITIALS
1 May 86		1 May 86	

AF FORM JUL 72 1841

MONITOR/OPERATE AND MAINTAIN ELECTRODIALYSIS DEMINERALIZER UNIT

OBJECTIVES

Given information and an electrodialysis demineralization unit, work as a team to monitor/operate the unit, with no more than three instructor assists.

Given information and an electrodialysis demineralizer, work as a team to maintain the unit, with no more than two instructor assists.

PROGRESS CHECK III-5-a

INSTRUCTIONS: Given step-by-step procedures and working as a member of a team, operate the electrodialysis unit. The instructor may assist three times during the unit's operation.

Using the instructions below, operate the electrodialysis demineralization unit.

SAFETY PRECAUTIONS

1. Initially, and each time the unit is moved or dismantled, check the ground connections before turning on DC power. The skid frame should be grounded to the building ground.
2. Do not touch wet stack sides or electrode tabs when the DC power is on.
3. Always wear rubber gloves when voltage probing the membrane stack.
4. Never apply DC voltage to the membrane stack when there is no water flow through the stack.
5. It is normal for the DC amperes to DROP when the feedwater temperature DROPS. NEVER increase DC stack voltage as feedwater temperature drops in an attempt to raise amperage to that recorded at the higher temperature UNLESS you have received specific instructions to do so from Ionics.
6. It is normal for the DC amperage to RISE when the feedwater temperature RISES. If the temperature rises less than 10°F, it is not necessary to lower the DC voltage when this happens. If the feedwater temperature RISES more than 10°F, the DC voltage should be lowered until the DC amperage returns to normal UNLESS you have received specific instructions from Ionics to the contrary.
7. Never allow oil, organic solutions, solvents, detergents, sewage, nitric acid, bleach or other strong oxidizing agents to come in contact with the membranes and spacers unless directed by an Ionics Representative. Membranes can be DAMAGED if operated on a feedwater containing even 0.1 ppm free available chlorine.
8. ALWAYS keep membranes wet.
9. When washing down the area, never direct a hose on the membrane stack when the DC power is on.
10. Feedwater containing Calgon or other hexametaphosphates will cause higher membrane stack resistance. Avoid operation when these are present.

OPERATION OF E.D. UNIT

Using the instructions below, operate the E.D. unit.

1. PREOPERATION PROCEDURES

   NOTE: Observe safety precautions.

   a. Close the float switch simulator.

   b. Inspect the unit for any sign of damage or unsafe conditions.

   c. Check to see that the unit is connected to a 110-volt outlet and the switch on the console is in the off position.

2. OPERATION PROCEDURES

   NOTE: Observe safety precautions and follow the instructions below.

   a. Open the plug valves PV-1 in the product flush and raw feed waterlines.

   b. Put the switch S-1 on the console in the on position.

c. Allow a waiting time as high as 15 minutes for the unit to start producing water.

d. Fill out the attached log sheet.

3. SHUTDOWN OPERATION

a. Put the switch S1 on the console in the off position.

b. Close plug valves on the product flush and raw feed water line.

4. LOG SHEET FOR E.D. OPERATION.

a. DATE/TIME								
b. PRODUCT WATER TEMP °F								
c. PRODUCTION FLOW RATE								
d. CURRENT (AMPERES)								
e. PRESSURES	BEFORE FILTERS							
	AFTER FILTERS							

PROGRESS CHECK III-5-b

INSTRUCTIONS: Using an electrodialysis trainer and working as a team member, perform maintenance procedures as outlined in the operator's maintenance checklist. Instructor may assist no more than two times during operation.

1. TDS Test

   a. Draw product water from unit.

   b. Using specific conductance meter perform a TDS test on product water.

   Purpose of Test: To measure the specific conductance of a water sample as a relative measure of the dissolved ionizable solids as NaCl equivalent.

   Method of Testing: Electric Conductivity Meter

   (1) Principles of Test

   (a) Water without any dissolved solids is a very poor conductor of electricity.

   (b) Water which contains dissolved ionizable solids will conduct electricity in approximate proportion of the concentration of the ions.

   (c) A conductivity meter is used to measure the micromhos conductivity.

   (2) Equipment:

   (a) Solo-bridge (specific conductivity meter)

   (b) Prepare conductivity cell probes as follows:

   1 Low range probes for distilled or demineralized water samples.

   2 High range probes for raw or treated water samples.

   (c) Two, footed cylinders (beakers may be used if sufficiently deep enough to allow submergence of air vent on probes).

   (d) Conversion chart.

   (e) Thermometer.

   Reagents: None except for product water, and demineralized water for probe storage and cleansing.

   (3) Procedure:

   (a) Fill container two thirds full of sample.

   (b) Select probes with low range depending on sample.

   (c) Rinse the probes in one of the cylinders with demineralized water.

   (d) Place probes in second cylinder.

   (e) Plug in the meter and turn switch to "ON" position.

   (f) Check temperature of sample used to rinse probes.

   (g) Set temperature control on meter to temperature obtained in step f.

   (h) Jiggle the probes in sample until all of the air bubbles escape through the vent holes. Keep probes submerged below vent hole level.

(i) Turn the conductivity scale knob until the dark area of the eye or null indicator is at its widest size.

(j) Read the meter and record the micromhos specific conductivity of sample.

(k) Turn switch to the off position and unplug the meter.

(l) Rinse the probes in distilled water and store.

(m) Use the conversion chart that is furnished with the meter to convert specific conductivity to PPM NaCl equivalent.

(n) Record results:

______________________ Micromhos specific conductivity.

______________________ mg/l NaCl equivalent.

2. Electro membrane stack probing.

a. With unit operating setup the multimeter with instructor assistance.

b. Probing stack

(1) Holding black lead in left hand, and red lead in right, about one inch apart from each other.

(2) Touch the membrane stack from left to right at one to two inch intervals across the entire stack. Note ohms change on green scale as you progress across the stack. Record three readings.

(3) Ohm readings across stack. For left ________ ohms. Middle ________ ohms. For right ________ ohms.

c. Disconnect probes from multimeter box, store away inside the box.

d. Turn off unit, switch __________ and switch __________.

e. Turn off feed PGV-1 and product flush PGV-2.

f. Turn off major electrical control box on wall.

3. Stack disassembly and assembly.

The following is a step-by-step procedure for disassembly and assembly of a membrane stack.

NOTE: Read all of the following instructions thoroughly before attempting any maintenance on a membrane stack.

a. Disassembly

(1) Remove the stack end plate.

(2) Remove the plastic end block. Do not lay the block on the plastic hose connectors.

(3) Remove the top electrode gasket and top electrode.

(4) Before actual membrane and spacer removal, the operator should wash his hands to prevent bacterial contamination of the membranes.

(5) The disassembly can be done either in sections or in pairs.

(6) To maintain proper order for reassembly, turn the membranes over when placing them down during disassembly. This holds true for both pair and section disassembly.

(7) When disassembling a two stage stack, the procedure listed above will be used for the second stage also.

b. Assembly Precautions

(1) To prevent assembly errors, place a schematic of the stack in a location where it can be referred to constantly during the assembly.

(2) Alternate anion and cation membranes except at the electrodes.

(3) The platinized side of the ANODE faces the center of the stack.

(4) Check manifold alignment carefully.

(5) Do not introduce foreign material to the stack.

c. Assembly

(1) When replacing the membranes, either by pairs or by sections, the operator must turn the membranes over so they will be in the right position.

(2) Carefully line up the membranes and spacers so that the manifold holes form a vertical flow leader for the entering streams.

(3) When assembling a two stage stack, the above procedures are followed for the second stage.

(4) Replace the top electrode section and top end blocks in the reverse order of disassembly.

(5) Tighten binding bolts alternately and only enough to stop excessive leaking with the pump on.

-----STOP-----

Before proceeding any further have the instructor check your work.

________________Instr Initials

FIELD WATER PURIFICATION UNITS

OBJECTIVES

Given a sketch of a proposed water point and site selection criteria, locate and identify the correct site to set up the unit according to TM5-700. Three of four must be correct.

Given a diagram and information related to the ERDLATOR, locate and identify components IAW TO 40W4-9-1. Ten of twelve must be correct.

Using TO 40W4-9-1 and information related to the operation of the ERDLATOR, match statements pertaining to the operation of the unit. Twelve of fifteen must be correct.

Using TO 40W4-9-1, complete statements pertaining to preventative maintenance procedures and troubleshooting operational problems of a 600 gph ERDLATOR. Nine of fifteen must be correct.

Given a diagram and information related to the Reverse Osmosis Water Purification Unit (ROWPU), locate and identify the ROWPU components IAW TO 40W4-13-1. Seven of eleven must be correct.

Using TO 40W 4-13-1 and related information, write the correct procedures used to perform maintenance on the Reverse Osmosis Water Purification Unit. Six of ten procedures must be correct.

PROGRESS CHECK III-6-a

INSTRUCTIONS: Given site selection criteria, your notes, and TM 5-700, select the correct site to position the WPU. Place the number in the selected area of your best choice. Three of the four must be correct.

1 RAW WATER PUMP

2 600 GPH WATER PURIFICATION UNIT

3 CLEAR WELL (STORAGE TANKS)

4 DISTRIBUTION PUMP WITH NOZZLES

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

_______Instr initials

PROGRESS CHECK III-6-b

INSTRUCTIONS: Using the drawing of the (ERDLATOR) field water purification tank (figure 6-1) with numbered items and a list of components, match the components to the numbered items. Ten of twelve components must be correct.

Figure 6-1. Erdlator

Components

a. Downcomer tube
b. Baffle rings
c. Circular discs
d. Influent launder
e. Agitator shaft
f. Separator zone
g. Sludge concentrator tank
h. Effluent launder
i. Baffle
j. Wet well
k. Mixing zone
l. Clarification zone

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

______Instr initials

PROGRESS CHECK III-6c

INSTRUCTIONS: Column A list statements, chemicals and actions pertaining to the operation of the ERDLATOR. Column B contains phases which match the statements in Column A. Complete each entry in Column A by placing the corresponding letter of Column B in the space provided. Each letter may be used once, more than once, or not at all. Twelve of fifteen must be correct.

COLUMN A

___ 1. Recharge slurry feeder

___ 2. Must reposition this component in order to decrease the rotation of the slurry blanket

___ 3. Ferric Chloride

___ 4. Limestone

___ 5. Recharge chemical solution feeders

___ 6. Component which receives flocculent slurry flows from the ERDLATOR tank

___ 7. Used to precoat filter

___ 8. Pressure gauge reading which indicates backwashing of filter is necessary

___ 9. Ratio of ferric chloride to one gallon of water

___ 10. Ratio of calcium hypochlorite to one gallon of water

___ 11. Permissable to start drive motor

___ 12. Action required to drain all water from slurry feeders

___ 13. In cold weather, refrain from touching with bare hands

___ 14. Mix chemicals

___ 15. Required for extended shutdown

COLUMN B

a. Sludge concentration tank

b. One foot of water in tank

c. Coagulant aid

d. Coagulant

e. Anti-coagulant

f. Diatomaceous earth

g. Every 60 minutes

h. 5 psi

i. Every 45 minutes

j. Lift the slurry float

k. As required

l. Depress the slurry float

m. 10 psi

n. When tank contains one foot of water

o. Metal parts

p. Agitator drive belt

q. In well ventilated area

r. When tank is one third full

s. 1/3 lb per gallon

t. 0.05 lb per gallon

u. Remove filters, clean dry unit

v. Remove filters

w. Remove vent plugs

PROGRESS CHECK III-6-d

INSTRUCTIONS: Complete the following statements pertaining to preventive maintenance and troubleshooting of the Erdalator unit using TO 40W4-9-1 and study guide. Nine of 15 must be correct.

1. The first inspection that is done before starting the ERDLATOR is a/an ______________________________.

2. Responsibility for performance of preventive maintenance service rests with the ____________________, the entire chain of command from the ____________________ ____________________ to ____________________ ____________________.

3. According to TO 40W4-9-1 inspection of the generator falls under ________________ service.

4. If the generator does not turn on, check to see if the unit is receiving ______________________________.

5. How often should the drain lines be inspected?

6. How often should the fire extinguisher be checked?

7. What type of service must be done if the unit is to be shut down?

8. If the trailer has loose trailer mounting nuts what should you do?

9. How often should the low water level switch be serviced/inspected for major problems?

10. List five things that could go wrong with the solution feeders.

11. If the chemical slurry feeder is clogged, what do you do to restore it to operation?

12. If there is insufficient solution coming from the solution feeder what could be the probable causes for this?

13. What are two probable causes for the water after the filter not being clear?

14. List two reasons why plug valves leak water or draw air.

15. List two reasons why diatomite filter runs too short or too long.

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

______Instr initials

PROGRESS CHECK III-6-e

INSTRUCTIONS: Match the numbered areas on the RO unit to the list of components. Seven of 11 must be correct. TO 40W4-13-1 may be used. All items will be used only once.

Figure 6-3. RO Unit

Components:

a. Distribution pump ______________

b. Paddles ______________

c. NBC tanks __________

d. Folded product water tanks ________

e. Sledge hammer ______________

f. Raw water pump ______________

g. Utility pail ______________

h. Backwash pump ______________

i. Storage boxes ______________

j. Brine tank ______________

k. Rubber hose ______________

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

______Instr initials

PROGRESS CHECK III-6-f

INSTRUCTIONS: Using TO 40W4-13-1, chapter 3, section III, write the correct procedures used to perform maintenance on the Reverse Osmosis Unit. Six of 10 must be correct.

1. When must the RO elements be replaced?

2. What inspection procedures are followed when changing RO elements?

3. List the first three steps when changing cartridge filter tube elements.

4. If filters leak after being replaced, what maintenance procedures need to be followed?

5. What four maintenance procedures are followed in cleaning the backwash pump strainer?

6. What is a rupture disc and where is it located?

7. What must you do if the rupture disc opens during operation of ROWPU?

8. What type of maintenance must be performed if you are inspecting, cleaning, or if a leak appears around the handhole covers?

9. List the three major steps needed when replacing handhole gaskets.

10. What items must be used to repair a leak on the canvas product water and brine water tanks?

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

_______Instr initials

SWIMMING POOLS

OBJECTIVES

Using information from AFR 91-26 relating to the operational principles of swimming pools, match facts and terms to the identifying statements. Eight of twelve must be correct.

Identify the construction features and major components of the pool by making written responses to complete a diagram. Fifteen of twenty responses must be correct.

Complete a checklist by listing the maintenance requirements of the pools, and components, with no more than one instructor assist.

PROGRESS CHECK III-7-a

INSTRUCTIONS: Match the statements in Column A to the terms in Column B, concerning operational principles of swimming pools. Eight of 12 must be correct. Some items may be used once, more than once or not at all.

COLUMN A. STATEMENTS

_____ 1. Chemical used as coagulant in swimming pool operation.

_____ 2. Chemical used as a disinfectant for swimming pools.

_____ 3. Causes cloudiness in pool water.

_____ 4. pH range in a swimming pool.

_____ 5. Indoor swimming pool temperature should not exceed.

_____ 6. Air Force swimming pool log sheet number.

_____ 7. Items to be inspected before pool is opened.

_____ 8. Used to check turbidity.

_____ 9. Time allowed for water filtration.

_____ 10. Floating material is removed by.

_____ 11. A guide used for the operation and backwashing of the filter.

_____ 12. Used to prevent damage to the pool during freezing temperatures.

COLUMN B. TERMS

a. logs

b. 6.8 to 8.2

c. 7.2 to 7.8

d. Standard operational procedures

e. Components

f. Base medical authorities

g. Pool area

h. Flooding the pool

i. Aluminum sulfate

j. Supplies

k. Black disc

l. 78°

m. Undissolved chemicals

n. Chlorine

o. 6 to 8 hours

p. AF Form 708

q. Medical equipment

r. 71°

s. AFM 85-13

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

______Instr initials

PROGRESS CHECK III-7-b

INSTRUCTIONS: Complete the following diagram by identifying the major parts of the swimming pool and filter components.

Figure 7-1. Pool

a. Erdlator

b. turbidity marker

c. Drain

d. Return inlet

e. ROWPU

f. Fill pipe

g. Shower/dressingroom

h. Pump room

i. Wading pool

j. Overflow trough

k. Lane indicators

l. Filter

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

_______Instr initials

PROGRESS CHECKLIST III-7-c

MAINTENANCE CHECKLIST

PART 1

INSTRUCTIONS: During the field trip to the base swimming pool, observe and inspect the pool components. Using the list of pool components below, write the noticeable maintenance requirements of each item. Each item must have an answer.

POOL COMPONENT	CONDITION OR DIFFICIENCY NOTICED	CORRECTIVE ACTION
1. General housekeeping		
2. Safety items		
a. Guard rails		
b. Life preservers		
c. Signs		
d. Color codes		
e. Non-slip devices		
f. Water fountain		
g. Electricity		
h. Personnel authorized		
i. Horseplay		
j. Chemical storage		
k. Tools		
l. Others		
3. Pumps		
4. Piping		
5. Hair catcher		
6. Filter		
7. Feeders		
8. Safety equipment		
9. Forms		
10. Security		

-------------- STOP ----------------------

Before proceeding any further, have the instructor check your work.

______Instr initials

STUDY GUIDES/WORKBOOK
J3ABR56631 000-IV-1 thru 11

Technical Training

Environmental Support Specialist

WASTEWATER TREATMENT AND DISPOSAL

June 1984

3700 TECHNICAL TRAINING WING
3770th Technical Training Group
Sheppard Air Force Base, Texas

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

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EXPLANATION OF TERMS

Bacteria - A group of one cell organisms lacking chlorophyll. Bacteria are usually regarded as plants.

Aerobic - Bacteria that need oxygen to survive.

Anaerobic - Bacteria that do not need oxygen to survive.

Faculative anaerobic - Bacteria that adapt to growth in either absence or presence of oxygen.

Pathogenic - Bacteria that cause disease.

Detention - the period of time from when the wastewater enters a tank until it leaves the tank.

Digestion - the breaking down of water to a more stable form by bacteria.

Digested - Digested sludge has been stabilized enough through anaerobic decomposition to permit handling without any nuisance.

Effluent - Outlet of a plant or from any piece of equipment.

EPA - Environmental Protection Agency.

Grit - Inorganic matter such as sand, gravel, rock, etc.

Inorganic - Material that has no life or has never had life such as dirt, rock, minerals, etc.

Liquor - A mixture of activated sludge and wstewater in the aeration tank undergoing activated sludge treatment.

Organic - Any matter having had life such as skin, vegetable material and foods.

Pollution - A condition created by the presence of harmful material in water.

Pollutant - The harmful material itself.

Polluter - Person or activity which is not correctly disposing of its pollutant.

Potable - Water is said to be potable when it does not contain objectional pollution, contamination, minerals or infective agents and is considered satisfactory for domestic consumption.

Purification - The removal of objectionable matter from water by natural or artificial methods.

Septic - Sewage is said to be septic when undergoing putrefication under anaerobic conditions, foul smelling.

Supernatant - The liquid between the sludge on the bottom and the scum on top in a digester.

Treatment - The process of removing pollution from wastewater.

Preliminary - The removal of objects which are injurious to sewers, plant equipment and treatment processes.

Primary - The first major treatment in a wastewater plant, removal of the settleable solids.

Secondary - The removal of suspended solids by biological methods.

Tertiary - The removal of finely divided solids which will not settle but may be removed by coagulation or filtration.

Wastewater - The spent water of a community. From the standpoint of source, it may be a combination of the liquid and water-carried wastes from residences, commercial buildings, industrial plants, together with and groundwater, surface water and storm water that may be present.

NOTE: For additional definition of terms pertaining to wastewater treatment, see glossary in AFM 91-32.

3770th Technical Training Group
Sheppard Air Force Base, Texas

SW J3ABR56631 000-IV-1

CHARACTERISTICS OF WASTEWATER

OBJECTIVE

Given information concerning the characteristics and composition of wastewater and a list of incomplete statements and phrases, write the terms or phrases to complete each statement. Fifteen of the twenty statements must be correct.

INTRODUCTION

It is the function of the base wastewater treatment plant to collect wastes from households, streets, businesses and industry on an Air Force base. The wastewater treatment plant is responsible to provide for inoffensive and reliable collection and safe disposal of these water carried wastes. The treatment of wastewater begins where the treatment of the water supply ends. All treatment of wastewater is important. It comes from the drains and pipes of the base collection system, goes through your treatment plant, and ends in the stream or ground water which receives the wastewater effluent.

The method for wastewater disposal will vary with the situation. Wastewater disposal is not a glamorous operation. A sewer line brings nothing to a small town or city, its location is underground where no one will see it, and its only service is to take away that which is not wanted. If you think about it, the more efficient the wastewater plant is, the less noticeable it is. When you leave here you may be assigned to a base wastewater plant. Your knowledge of classes and sources of wastewater will help you become a better plant operator. Wastewater is made up of various types of wastes from different areas, and may come from a base or a city. These different types of wastes are classified as either domestic wastewater or industrial wastewater. When you graduate from this course, you will be going to a base and perhaps be operating a waste treatment plant. You must be able to recognize the equipment used in the plant and how it operates. These subjects will be covered under the following topics.

INFORMATION

COMPOSITIONS

Domestic

Domestic waste is liquid or semi-solid wastes from latrines, slop sinks, kitchens, showers and other sanitary conveniences. Storm run-off is not normally included in sanitary wastewater. Although, wastewater contains considerable floating matter including fecal solids, paper, grease, and kitchen refuse, about 99.9% by weight of the total volume is water. Wastewater generally has a higher temperature than the water supply. When fresh, it is usually gray and almost odorless; when stale and septic, wastewater is dark and has a rotten or putrid smell. Ordinarily turbid, sanitary wastewater becomes more septic as it grows older.

Industrial

Plant operators should be familiar with all the industrial operations at their base. These wastes can be very hazardous to the wastewater plant operators as well as to the treatment plant and the collection system. It is advisable to pretreat industrial waste before it enters the collection system. There will be times when this is not possible, because of the size of the base. Industrial wastes can be very low or high in pH because of acids/bases used in their processes.

Industrial waste may include liquids such as acids, alkalines, phenoles, oils and cleaning solutions, which result from aircraft washing and industrial operations. When the volume of waste is small, it is normaly disposed of through the sanitary wastewater treatment plant. In some cases, however, it is necessary that separate industrial waste treatment plants be constructed.

CHARACTERISTICS OF DOMESTIC AND INDUSTRIAL WASTEWATER

The wastewater plant operator on an Air Force base must know the wastewater characteristics and the different material in it. Knowing these factors, the operator can provide the right treatment for their base. How your wastewater plant will operate is going to be determined by the changes that the operator makes to the plant as the different types of wastewater enter. The contents of wastewater depend largely upon where it comes from. The general term wastewater is used to describe all waste materials flowing through the sanitary wastewater system. It is largely the water supply of a base after it has been fouled by many uses.

Domestic and industrial wastewater has similar effects on plant operation. These effects include the clogging of pumps, coating of equipment with grease, reducing flow, blocking flow, creating offensive odors, increasing the biochemical oxygen demand, and raising or lowering the pH. One important difference between the effects of domestic and industrial waste is that industrial waste may kill the helpful bacteria when it enters a domestic waste plant in large quantities.

Materials frequently contained in sewage are grouped under the following headings:

1. Liquids
    a. Oil
    b. Soaps
    c. Acids
    d. Alkalies
    e. Gasoline
    f. Kerosene
    g. Milk
    h. Alcohol
2. Organic Matter
    a. Sticks
    b. Paper
    c. Leaves
    d. Cotton products
    e. Food stuff
    f. Fecal matter
    g. Small animals
    h. Plastic products
3. Inorganic Matter
    a. Rocks
    b. Gravel
    c. Sand
    d. Meal products
    e. Glass
    f. Metals

PHYSICAL PRINCIPLES AND PROCESSES

Wastewater usually contains a quantity of undigestible inorganic or mineral matter such as sand, gravel, glass, metal, and even some large organic matter that must be removed. The removing or grinding or shredding of this matter is referred to as physical principle. Sludge drying beds are also considered a physical treatment since evaporation takes place, and no chemical or biological process takes place. Grease removal is also a physical treatment. It can therefore be understood that any treatment the wastewater receives other than chemical or biological can be referred to as physical treatment.

We need to know about the equipment we use at a wastewater plant for the physical treatment processes. These include screens, shredders, grit removers, pre-aerators and measuring devices.

CHEMICAL PROCESSES

The use of chemicals in wastewater treatment is very limited. The most common chemical treatment is the addition of chlorine for disinfection of the plant effluent. Chlorine may also be used to control odors and help correct operational problems in the plant. Another chemical that may be used is lime. Lime is usually used to raise the pH in a digestor. Enough lime should be added to maintain the pH at about 7.0. Other chemicals may be used depending on the type of treatment, but these are the two most common.

BIOLOGICAL PROCESSES

Bacteria in wastewater are of three types: aerobes, which live and develop in the presence of free oxygen; anaerobes, which live and develop in the absence of oxygen; and facultative bacteria, which are active under either condition. Almost all wastewater bacteria feed on organic matter and their feeding activities aid in the process of decomposition. Some types of bacteria are pathogenic or disease-bearing; these usually originate in body wastes discharged by victims or carriers of infectious disease such as typhoid, dysentery, and cholera. The bacteria decompose or break down the solids into different compounds as a result of their feeding activity. Fresh wastewater contains enough free oxygen to support the aerobic bacteria.

SOURCES OF WASTE

Domestic Waste

This type of wastewater comes from all over the base area. It comes from the kitchen and bath rooms in the base housing area. It also comes from the dining halls and troop living areas on the base. The other source is from the buildings on base with latrines. Most of the wastewater being treated on Air Force bases will be of the domestic class.

Industrial Waste

This type of waste will be from the laundry and dry cleaning plants, metal cleaning and plating processes, paint spray booths, airplane and vehicle washing racks, plant boiler blowdowns, photo labs and fire fighting areas, etc.

NOTE: For additional information read AFM 91-32, Chapter 1, Introduction to Wastewater Treatment, Section 2 thru 4, para. 1.2.1 thru 1.4.5.

EXERCISE IV-1-1a

PART 1

INSTRUCTIONS

Answer the following questions on characteristics of wastewater.

1. What are two classes of wastewater?

   a. ______________________________

   b. ______________________________

2. Domestic wastewater comes from what specific place? ______________________________

3. Industrial wastewater comes from what specific place? ______________________________

4. What percent of wastewater by weight is water? ______________________________

5. What is the effect of industrial waste on a treatment plant? ______________________________

6. Name four sources of domestic wastewater.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

7. Name three organic materials.

a. ______________________________

b. ______________________________

c. ______________________________

8. Name three inorganic materials.

a. ______________________________

b. ______________________________

c. ______________________________

9. What is the color of fresh wastewater? ______________

10. How does the temperature of wastewater compare with that of the water supply?

____

____

11. Name the three treatment principles.

a. ______________________________

b. ______________________________

c. ______________________________

12. How does bacteria break wastewater down? ______________

____

13. Bacteria in wastewater are of what three types?

a. ______________________________

b. ______________________________

c. ______________________________

14. What is chlorine used for in wastewater? ______________

15. What is Hydrated lime used for? ______________

EXERCISE IV-1-1a

PART 2

INSTRUCTIONS

List under the three headings the materials frequently contained in wastewater.

1. Liquids
   a. ____________
   b. ____________
   c. ____________
   d. ____________
   e. ____________
   f. ____________
   g. ____________
   h. ____________

1. Organic Matter
   a. ____________
   b. ____________
   c. ____________
   d. ____________
   e. ____________
   f. ____________
   g. ____________
   h. ____________

3. Inorganic Matter
   a. ____________
   b. ____________
   c. ____________
   d. ____________

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

In this study guide/workbook you have become familiar with the classes and sources of wastewater. It is necessary that we have a safe, sanitary method of disposal. Some areas of the base will yield both classes of wastewater. Wastewater is made of various types of waste from different areas. This waste is either domestic or industrial. Domestic waste consists of waste from latrines, slop sinks, kitchens, showers and other sanitary conveniences. Industrial wastes consist of acids, oils and metal-treating solutions. In this study guide you have read about the principles of waste treatment and the equipment used.

REFERENCE

AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

3770 Technical Traing Group
Sheppard Air Force Base, Texas

SW J3ABR56631 000-IV-2

WASTEWATER PLANT SAFETY

OBJECTIVE

Given a list of unsafe conditions and violations, select the safe rule or practice to eliminate the violation. Seven of the ten must be correct.

INTRODUCTION

In this study guide/workbook we will discuss wastewater plant safety. The Occupation Safety and Health Act of 1970 first became law April 18, 1971. The purpose of the Act is to identify, eliminate or correct hazardous and unhealthy conditions. Correction of these conditions in the Air Force will save lives, provide better health and protect Air Force property. Wastewater plant safety management practices will be corrected according to OSHA recommendations.

INFORMATION

Safety Regulation

The Air Force complies with two agencies on safety. Policies already set by OSHA (Occupational Safety and Health Program) are not duplicated in AFOSH (Air Force Occupational and Health Program). You as a wastewater plant operater will comply with standards set by both agencies. OSHA specifies that each worker is responsible to follow safe procedures at all times. A worker is responsible for following safe procedures, properly using the safety equipment provided, and to perform their tasks in a safe manner.

Safety Programs

It is good management practice to have a safety program. A good safety program pays off in the long run. It will improve worker efficiency, it will keep morale up, and the workers will be on the job instead of off the job in a hospital. In the long run the Air Force medical costs will stay way down. In the Air Force Water and Wastewater treatment plant, operators can have as many accidents as other shops in the Air Force. This situation can be improved only by the combined efforts of all workers. Supervisors as well as workers must be alert at all times. Weekly safety briefings can be held by a water and a wastewater section. At these meetings, safety hazards are identified, discussed, and actions taken. Another method used for a safety program is, select one person from the workers as a representative to follow up on reported safety items. That person should be informed at all times of the updated action taken on safety by the supervisors. The accident we are trying to prevent, with good safety programs, may be yours!

Protective Equipment

Environmental Support personnel are responsible for using the safety equipment to the greatest practical extent. All new employees will be instructed as to the purpose and use of personal safety equipment. Correct use of the safety equipment will be understood by all employees. Personal safety equipment is designed to protect a person's eyes, face, head, nose, throat, lungs, ears, hands, feet and body. It doesn't matter how much safety equipment a person has, it will not protect a worker from unsafe actions or conditions. It can only supplement safe work or work habits.

Safety Rules and Practices

There are many safety rules and practices used in the Environmental field. Below are listed a few that you need to be familiar with to begin work in the wastewater treatment area.

1. Face and eye protection. All operators must wear approved glasses, goggles, or face shields during any job where harmful materials or chemicals could contact the face or eyes.

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2. Head protection. All wastewater plant personnel working in any areas where there is danger from falling, flying tools or other objects must wear approved hard hats.

3. Breathing protection. In all dusty areas, filter masks should be used to guard against dust from toxic material.

4. Hand and foot protection. When handling rough, sharp, hot or chemically active materials wear regular work gloves for protection from dirt, friction or scratches. Wear safety-toed shoes with non-skid soles to prevent slips. Always wear rubber boots with non-skid soles when working in wet areas.

5. Body protection. Overalls or coveralls are acceptable for most jobs. When working on ladders or scaffolding, use the buddy system to prevent falls.

6. Hearing protection. When noise exceeds specified levels, you must wear earpads or earplugs. These protective devices must be fitted by a competent hospital technician. Never wear cotton plugs, they are inadequate protection.

Hazardous Operations

Some of the dangers in Wastewater plants include, but are not limited to, the following:

1. Infectious diseases

2. Oxygen deficiency

3. Toxic gases

4. Explosive gases

5. Fire

6. Electrical shock

7. Too much noise

8. Physical injuries form falls, lifting, falling objects, tools and equipment

All the dangers listed above can happen at anytime in the plant. But the most common danger around a wastewater plant is gases. Below are listed but a few place where they exist.

1. Laboratories

2. Secondary treatment areas

3. Chlorine storage areas

4. Sludge digestion and storage tanks

5. Screening and shredding areas

6. Pump lift stations

7. Covered pits, wells or valve rooms

8. Manholes, especially deep ones

NOTE: Read the following additional information on Safety, using AFM 91-32, Chapter 17, Section 2, Identification of Hazards; Section 3, Protective Equipment, para. 17.3.1 - 17.3.3, para 17.3.6 - 17.3.7; Section 5, Treatment Plant Hazards, para. 17.5.1 - 17.5.2, para. 17.5.7 - 17.5.8.

EXERCISE IV-2-2a

PART 1

INSTRUCTIONS

Answer the following questions on Wastewater Plant safety.

1. What two agencies does the Air Force comply with on Safety? ____________________

2. What does a good safety program do for wastewater plant employees? ____________________

3. How can safety programs be improved in the wastewater shop? ____________________

4. What is personal safety equipment designed to protect? ____________________

5. What does the safety rule for face and eye protection state? ____________________

6. What does the safety rule for hearing protection state? ____________________

PART 2

INSTRUCTIONS

List below the common areas where the danger of wastewater plant gases will exist.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________

PART 3

INSTRUCTIONS

Use AFM 91-32 to answer the following questions. Answers listed below.

1. The wearing of ______________ ________________, in laboratories and where corrosive fumes exist, is prohibited.

2. Filter masks can't protect against ______________________ deficiency.

3. Ordinary work shoes should have ____________ ____________ soles to prevent ________________.

4. It is heavier than air and usually concentrates in low areas - __________________ ________________.

5. Always assume any manhole contains ____________________ until proven safe.

6. All gas burning equipment must be fitted with effective ____________ ___________.

7. Before pumping and lift station maintenance repair always __________ ____________ and ___________ ______________ all power.

8. Never start a positive displacement pump against a _____________ ________________ valve.

9. The ______________ ________________ of safety training seems most effective.

10. Phone numbers for base medical service should be __________________ posted above every phone in the treatment facility.

ANSWERS

Contact lens
Flame arrester
Hydrogen sulfide
Slips
Closed discharge
Lock out

Switch off
Permanently
Oxygen
Non-skid
Gas
Buddy system

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

In this study guide/workbook you have become familiar with Wastewater Plant Safety. You, as the Wasterwater plant operator must comply with the safety programs set up by your supervisor. You must at all times be familiar with OSHA and AFOSH programs. As a Wastewater plant operator, know your protective equipment, Safty rules and practices. Know what areas of the plant produces hazardous operations and the precautons that you can take the guard against injury or even death.

REFERENCE

AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

3770 Technical Training Group
Sheppard Air Force Base, Texas

SW J3ABR56631 000-IV-3

POLLUTION CONTROL POLICIES AND PROGRAM

OBJECTIVE

Given information concerning Environmental Pollution Control Policies and Programs and a list of incomplete statements, write the phrase or term to complete each statement. Seven of the ten must be correct.

Given information related to hazardous waste material, select the phrase or term which correctly answers written statements. Seven of the ten answers must be correct.

INTRODUCTION

It is the function of the base wastewater disposal plant to collect wastes from households, streets, businesses and industry on an Air Force base. The wastewater treatment plant is responsible to provide for inoffensive and reliable collection and safe disposal of these water carried wastes. The treatment of wastewater begins where the treatment of the water supply ends. All treatment of wastewater is important. It comes from the drains and pipes of the base collection system, goes through your treatment plant, and ends in the stream or ground water which receives the wastewater effluent.

INFORMATION

Why Controls Are Necessary

Operating the wastewater plant is more than collecting the wastewater from one place and discharging it at another place. As a wastewater plant operator you must have more than one skill. Skills in chemistry and lab work are necessary, as well as math and engineering. How much treatment wastewater must have before it is released to a stream or river can vary from no treatment at all, to treatment resulting in wastewater being brought to the quality of potable water. The purpose of having wastewater treatment is not to purify it completely, but to have a wastewater which can be released safely without bad odors and pollution of the receiving stream. One of the most important factors is the area in which the wastewater is discharged. The wastewater plant operator must treat the wastewater so that together with the natural self-purification action, the water receiving the effluent is safe. We must keep in mind that wastewater treatment means much more than having safe drinking water. It helps to protect the water supply for livestock purposes. Livestock herds have been completely destroyed by bacteria that got into their water supply.

Federal and State Regulations

A permit is not a license to pollute. We must keep in mind that a permit regulates what may be discharged and how much. It sets limits for the plant discharge to a stream. The permit also requires wastewater treatment plant operators to check the plant effluent and report the amount and nature of all waste. What group sets these controls that all plants must comply with? NPDES (National Pollutant Discharge Elimination System), this new permit system of 1972, replaces the old permit system of 1899, Refuse Act. This new permit system is an effort to do away with water pollution. This law will require industries to use the best practicable method to control their water pollution. This law will also require publicly-owned wastewater treatment plants to give a minimum of secondary wastewater treatment. If our rivers, lakes and streams are still being polluted, then EPA will set even more stringent laws on those pollution sources so that those standards will be met. Now, if a company, city or town does not heed these laws, they can be fined. They could be fined up to 10,000 dollars a day. If they keep it up, this could bring a fine up to 25,000 dollars a day and at least one year in prison for the first offense. If they should repeat the violation then it could be a fine of 50,000 dollars a day and two years in prison. EPA can issue tickets that will be backed up in Federal courts. The NPDES permit lets concerned citizens find out what an industry or Air Force base is discharging into the water and what he or she can do to stop the pollution or make the polluter meet legal requirements.

Who is EPA? (Environmental Protection Agency) EPA is required to have nationwide wastewater effluent limitation. EPA has the right to refuse a permit if the permit does not comply with the law or EPA regulations. EPA also has the right to refuse a permit, if the effluent being discharged runs into another state's river. It's illegal under any circumstances to discharge unwanted waste products into the nation's waters, except under an NPDES permit. Pollutants covered by this permit are: Solid waste, incinerator residue, wastewater, garbage, sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal and agricultural wastes discharged into water.

The next agency we need to talk about is the state agency. A state can operate its own permit program. However, it must call for treatment at least equal to that the EPA requires. The state must have the power to enter, look at, and monitor the sources of pollution. It also must be able to require the polluters to install monitoring equipment and to keep records and file reports. The state must have an EPA program to furnish the public with quality water. The state's permit program must let the public see, at anytime, the fact sheets, discharge reports and the permits. The last party we need to talk about in the chain is the local agency. Concerned citizens can have a great effect in the fight for a cleaner environment. The citizen can monitor wastewater effluent given off by a wastewater plant. The citizen can work to insure that wastewater control people have enough money and staff to ensure that wastewater control laws are enforced. The local agency can make sure polluters move forward on wastewater treatment and are meeting EPA standards. They can request and take part in public hearings when necessary. They can report any violations of permits to control agencies, if all else fails, they can use their right to take court action. To protect the health and comfort of the public, wastewater must be collected, then treated, and then disposed of without creating a health hazard.

In this study guide/workbook you have learned why wastewater controls are necessary to keep our streams, lakes, rivers and oceans free from pollution. Your job as a wastewater treatment plant operator is an important one. The treatment you give the effluent will mean more safe drinking water for the public. It will also insure a more safe water supply for livestock. Industrial wastes give off excess odors and carry many toxic materials to your wastewater plant. We are lucky in the Air Force to have good treatment facilities for our wastewater.

Wastewater pollution controls set a limit on the plant discharge to a stream. It is our duty to check the plant effluent and report the amount and nature of all waste. The NPDES issues permits in which they prevent, reduce and do away with water pollution. This law was issued to permit industries to use the best practicable method to control their water pollution. EPA has set stringent laws on these pollution sources, those standards must be met. Towns and cities may be fined so much per day as long as they continue to put their wastes into a water source.

The state has the power to enter, to look at and to monitor the sources of pollution. The state EPA must have a program to give the pulbic a good quality drinking water.

The local agency is run by the citizens of the community. The local people can report any violations of their treatment systems to a higher agency. They also have the right to take court action against any polluters.

Military Requirements

Wastewater treatment plants on an Air Force base must comply with all rules and regulations the same as civilian treatment plants. In executive order 11752 the president has stated that it is the intent that the Federal Government in the design, operation and maintenance of its facilities shall provide leadership in the nationwide effort to protect and enhance the quality of our air and water resources. This means that an Air Force base should exceed the standards required of their civilian counterparts.

The Department of the Air Force has established in AFR 19-1, Environmental Policies for Environmental Protection and Pollution Control. The Air Force will eliminate or control environmental pollutants caused by or resulting from Air Force operations. You as a Wastewater plant operator will help prevent and control pollution. You will help support local community polluton programs. As a plant operator you will reduce or eliminate waste at generating points, help keep chemicals and materials that you order for use at your base from causing pollution. an Air Force member, comply fully with all Air Force directives on polluton control. Exempt certain areas from control standards in the interest of national security. These actions must be justified and approved and must include recommendations of federal, state, and local pollution control agencies. As a wastewater plant operator, you must discharge or dispose of wastes in a manner which does not affect the health of people, result in harm to animals or wildlife, and last, result in ground water contamination.

Wastewater Pollution Control

The organic nature of human and domestic wastes cause the Biochemical Oxygen (BOD) of the stream that receives the effluent from the wastewater plant to run high. The oxygen demand is placed there by large amounts of organic contaminants and suspended organic solids present in the waste. The demand for oxygen may be great enough to exhaust the oxygen resources of the receiving waters, create unpleasant taste and odors, and lead to septic conditions. To protect the health and comfort of the public, wastewater must be collected, treated and disposed of without creating a nuisance or a health hazard. Wastewater is usually discharged from dwellings and commerical buildings.

Maintain and Submit Forms as Required by Directives

Records are used to find the best operating controls for a wastewater plant, also you need records for the plant in case you have trouble with it in the future. Records are also used in court if a law suit is filed against the treatment plant. There are three records, they are: Physical Records, Maintenance Records and Performance Records.

Physical Records. These records include operation and maintenance, actual plans and blueprints for the plant, shop drawings, O&M guides from equipment manufacturers, costs for all units. These O&M manuals must meet the requirements of "Considerations for Preparation of Operation and Maintenance Manuals," USEPA, Washington, D.C. 1974.

Maintenance Records. One of the key steps in a good maintenance program is keeping records. "Preventive" maintenance in the treatment plant can reduce costly repairs and "down time" on equipment. A record of all equipment in the plant must be made. These records may be kept in the recurring maintenance program. This information may include the following; where the equipment is located in the plant, the name and address of the manufacturer or supplier, the cost, and when it was installed. The file should also have the type, model, serial, and any other code numbers, along with the capacity or size rating. This data will be used when planning a maintenance schedule and as a maintenance checklist when you work on the equipment.

Performance Records. There are three types of performance records: Lab records, operator's log and NPDES forms. A complete set of lab records should be kept for all lab tests. A monthly or quarterly report is required at all plants. A monthly report is required for all wastewater plants on a military installation. The operator should report on special features of the treatment plant under the blank columns on the log. The AF Form 1462, Sewage Utility Operating Log (General); AF Form 1463, Sewage Utility Operating Log (Supplementary), these forms will be covered more in detail later in the study guide.

NPDES. Every treatment plant which discharges to a body of water must get an NPDES permit from EPA or designated state agency. The treatment plant must submit a monthly or quarterly report to EPA or designated state agency with all the lab tests required by the permit. These reports and lab records must be kept for at least three years.

EXERCISE IV-3-3a

INSTRUCTIONS

Answer the following questions on pollution control policies.

1. What are four skills you need as a wastewater plant operator?
   a.
   b.
   c.
   d.
2. What is the purpose of having wastewater treatment?
3. What does AFR 19-1 state?
4. A permit is not a license to .
5. What does NPDES stand for?
6. When does EPA have the right to refuse a permit?
7. What are the three pollutants covered by the NPDES permit?
   a.
   b.
   c.
8. What power does the state have over the effluent leaving a wastewater plant?
9. What part does the local citizen play in wastewater treatment?
10. To protect the health and comfort of the public, wastewater must be

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

Types of Hazardous Wastes

You as a wastewater plant operator in the Air Force will at sometime have to treat hazardous waste. Many different types of hazardous wastes may be sent to the treatment plant. We will cover general areas of hazardous waste in this study guide/workbook that you will be required to treat at your wastewater plant.

Sources of Hazardous Wastes

Hazardous wastewater can come from many places at a military base. These include, but are not limited to, paint stripping, metal plating, aircraft cleaning, photographic processing, laundries, petroleum oil lines, storage and transfer. Here are the most common problems in hazardous wastes:

a. Soluble organics which deplete DO (dissolved oxygen)

b. Soluble minerals which result in bad taste and odor in water supplies

c. Toxic substances

d. Color and turbidity

e. Oil, grease and scum

f. Acids and Alkalies

g. Heat

h. Substances that will burn or explode

Disposal Methods

The Environmental Protection Agency (EPA) has set pretreatment standards for many hazardous wastes. These standards are set forth to protect the domestic wastewater treatment plant and also to help prevent the discharge of hazardous wastes through the plant to receiving waters. Hazardous wastes may contain high amounts of solvents, sludge, oils, grease, acids and alkalies. Pretreatment units should be located at the areas where hazardous waste is thought to be discharged. The ways of pretreating these wastes are discussed below.

Containment and Storage

Physical Pretreatment. The normal techniques used for hazardous wastes are screening, grit removal, sedimentation, adsorption and oil-water gravity separation. Filtration can be used as a pretreatment method along with oil-water separators.

Chemical Treatment. Chemical treatment may include mixing, coagulating and settling coloidal and suspended solids, breaking of oil and grease build-ups, neutralizing acidic or basic wastes, oxidizing some organic and inorganic pollutants, sludge treatments and ion exchange.

Reducing Waste Strength and Volume. Discharges of hazardous waste can often be reduced by careful inspection of and minor changes to the operation of the process. One way to reduce the strength of hazardous wastes is to segregate it. Some commercial "reclaimers" may also pick up these wastes. Another way is to mix the hazardous waste. Mixing helps prevent short circuiting and reduces peaks in waste strength.

Safety in Handling/Treating Hazardous Waste

All wastewater personnel should wear protective clothing and goggles to protect the skin and eyes when using chemnicals. There are many chemicals in hazardous waste that will irritate the eyes, nose and lungs and will dry the skin. Many of these chemicals are used to treat hazardous waste products. Areas of the body that come in contact with these chemicals are to be washed from 15 minutes to two hours as a general rule. When handling most chemicals be sure to have a well ventilated area, this is also true in storing hazardous chemicals. One chemical that is used in treating hazardous waste is Sulfur Dioxide (SO_2). All safety items that should be worn when handling this chemical are; ventilation, safety goggles, approved safety shoes and rubber gloves.

In emergencies, a self-contained breathing mask should be available. Contact a doctor if anyone has a doubt as to the amount of Sulfur Dioxide they have been exposed to.

EXERCISE IV-3-3b

INSTRUCTIONS

Select the phrase or item which correctly answers the written statement.

1. One area that hazardous wastes can come from is _____________.
2. One of the most common problems in hazardous waste is _______________.
3. Pretreatment units should be located at the areas where hazardous waste is thought to be ______________.
4. The area that may include mixing, coagulating and breaking of oil and grease build-ups is _______________.
5. One way to reduce the strength of hazardous waste is to __________.
6. When mixing chemicals personnel should wear at least what two pieces of protective equipment? They are ____________________________________.

a. discharged

b. toxic substances

c. metal plating shops

d. segregate

e. chemical treatment

f. protective clothing and goggles

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

In this study guide/workbook you have become familiar with the Pollution Control policies and programs. The study guide has covered information related to hazardous waste. It is important that we are able to treat hazardous wastes at the Wastewater plant. We must be aware of some of the rules involved with agenices of the Federal government. You must be aware of the sources, disposal methods, containment and storage and how to use safety methods when working with hazardous waste.

REFERENCE

AFP 19-5, Environmental Quality Control Handbook

AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

3770th Technical Training Group
Sheppard Air Force Base, Texas

SW J3ABR56631 000-IV-4

OPERATION AND MAINTENANCE OF SEPTIC TANKS

OBJECTIVE

Given a list of statements concerning the construction features, operational practices and maintenance of septic tanks complete each statement. Ten of the fifteen must be correct.

INTRODUCTION

In this study guide/workbook we will discuss the principles used to treat and dispose of small quantities of wastewater. Such processes are normally used at small installations. These processes can be accomplished by means of septic tanks and tile fields. The units are, for the most part, underground. The septic tank is adequate for using with a single building. Both the effluent and sludge produced by such treatments are potentially offense but, with careful design, construction, inspection and proper sludge removal, they can be made to operate without nuisance and with minimum attention. Septic tanks do not require continuous operation, and when installed and maintained properly, provide an efficient sanitary method of wastewater disposal.

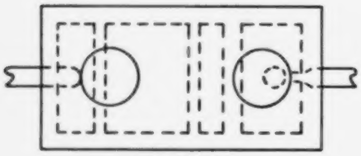
INFORMATION

Construction Features of Septic Tanks

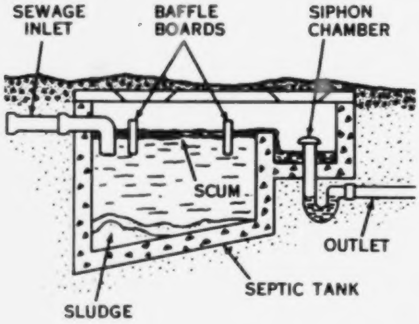
The size of the septic tank is determined by the amount of wastewater to be disposed. The minimum size for septic tanks is 500 gallons. Small tanks should have sufficient capacity to detain or hold wastewater for at least 24 hours at the average daily rate of flow, plus 25 percent of the daily flow added for sludge storage space. One of the most important factors in determining the size of a septic tank is the number of people to be served. It can be designed to serve a small group of people in a single building or up to the largest size where about 500 people can be served. Septic tanks serving large populations (approaching 300 or over) should have capacity for not less than 12 hours detention plus an extra capacity of 15 to 25 percent of the daily flow for sludge space. See Figure 4-1.

Operation of Septic Tanks

Septic tanks are simple in their operation. Wastewater flows into a tight (nonleaching) tank and is kept there long enough for the large solids to settle out. Solid matter settles to the bottom of the tank and partially decomposes producing liquids and gases. A slow, undisturbed flow through the septic tank provides for the separation of liquids and sludge and for bacterial action. The bacteria acting on the sludge are anaerobic. They work in the dark and where there is little or no air. Undigested solids form a residue of sludge on the tank bottom. From 40 to 60 percent of the incoming suspended solids are carried off suspended in the effluent. The tank inlet and outlet can be submerged to insure a reduced flow. Wooden baffle boards can be used for this purpose. A submerged outlet prevents scum which forms on top of the surface from passing out of the effluent. The effluent is the liquid discharged from the outlet.

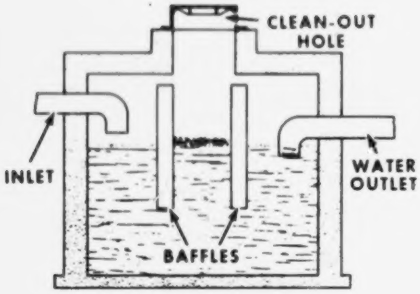


TOP VIEW


SEWAGE INLET
BAFFLE BOARDS
SIPHON CHAMBER
SCUM
OUTLET
SEPTIC TANK
SLUDGE

CROSS SECTION VIEW

CNE-001


CLEAN-OUT HOLE
INLET
WATER OUTLET
BAFFLES

CNE-002

Figure 4-1. Typical Shapes of Septic Tanks

Operation of Leaching Field

Records should be kept of each septic tank and disposal field inspection. These should include data of inspection, sludge and scum depth, conditions found, and corrective action taken.

Where small quantities of wastewater (less than 2000 gallons per day) are involved and favorable soil conditions exist, settled wastewater may be discharged into the ground through subsurface tile fields. Effluent from septic tanks of small installations are usually disposed of in this manner.

PROPER FUNCTIONING. Tile fields consisting of lines of cement or clay tile in the ground with open joints are used for disposal of settled wastewater into the ground. A fiber pipe with holes bored in the lower portion to allow drainage may be used for these drain lines. The following conditions are important for proper functioning of tile fields:

1. The ground water table is well below the level of the tile field.
2. The soil has satisfactory leaching characteristics within a few feet of the surface and extends several feet below the tile.
3. The subsurface drainage is away from the field.
4. The area is adequate.
5. There is no possibility of polluting drinking water supplies, particularly from shallow dug or driven wells in the vicinity.

TEST. Length of the tile and details of the filter trench generally depend upon the character of the soil. Soil leaching tests should be made at the site as described for leaching cesspools, except that the test hole should extend only to the approximate depth at which the tile lines are to be laid. For extensive tile fields several tests to determine the best location and average condition should be made. From test results the rate of wastewater application to the total bottom area of the tiled trenches may be taken from the following table. Soil testing over 30 minutes is not suitable. NOTE: See Figure 4-2.

FROST LINE. Placing tile below the frost line to prevent freezing is not necessary. Tile placed 18 inches below the ground operated successfully in New England for many years. Subsurface tile should never be laid below ground water level.

PIPE SIZE. Design and construction should provide for handling and storage of some solid material, eliminating as much as practicable the opportunity for clogging near pipe joints. Pipe 4 to 6 inches in diameter is recommended. The larger pipe gives greater storage capacity for soilds and larger area at the joint for solids to escape into the surrounding gravel.

Time for Water to Fall One Inch (Minutes)	Allowable Rate of Wastewater Application in Gallons Per Square Foot of Leaching Area
1	5.3
2	4.3
5	3.2
10	2.3
30	1.1

Figure 4-2

PIPE LAYING. To provide for free discharge of solids from the line to the filter trench the pipe must be laid with 3/8 inch clear openings. The top of the space is covered with tar paper or similar material to prevent entry of gravel. Bell and spigot pipe is easily laid to true line and grade. Good practice calls for breaking away 2/3 along the bottom of the bells at the joint and using small wood block spacers. The pipe is commonly laid at a slope of about 0.5 foot per 100 feet when taking the discharge directly from the septic tank and 0.3 foot per 100 feet when a dosing tank is used ahead of the field.

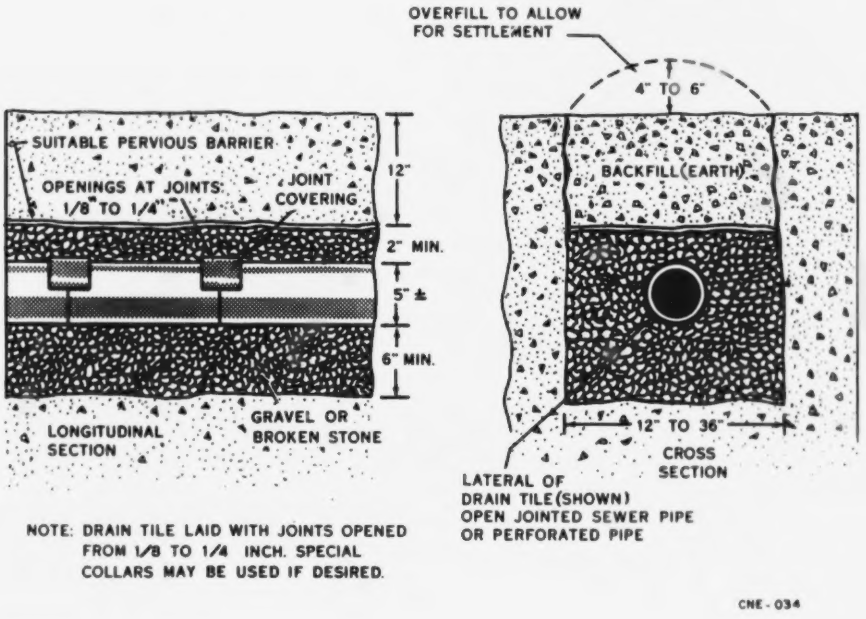
TRENCH WIDTHS. Minimum widths of trenches on the basis of soils are as follows:

1. Sand and sandy loam, 1 foot.
2. Loam, sand, and clay mixture, 2 feet.
3. Clay with some gravel, 3 feet.
4. Trenches should preferably not be over 2 feet deep.

LAYOUT. The layout of the piping system depends on the shape of the available area and the slope of the surface. A typical layout is shown in Figure 4-3. When tile is laid in sloping ground, flow must be divided equally to each lateral. Because of the small slope required for distribution lines and the advantage of having a fairly uniform depth of cover soil, individual lateral trenches follow the ground contour lines.

Tile fields are generally laid out in a herringbone pattern or with laterals at right angles to the main distributor. The distance between laterals should not be less than three (3) times the width of the trench. A distribution box at the head of the disposal field will insure equal distribution of flow to the laterals.

BEDS. The tile is laid on a bed of screened coarse gravel 6 inches deep with 3 inches of coarse gravel around and over the pipe. Coarse screened stone passing a 2 1/2 inch mesh and retained on a 3/4 inch mesh is recommended. This gravel bed gives a relatively large percentage of voids into which the solids may pass and collect before the effective leaching area becomes seriously clogged. The soil which fills the trench must not fill the voids in the coarse screened gravel around the pipe. A 3-inch layer of medium screened gravel over the coarse stone and 3 inches of either fine screened gravel of suitable bankrun gravel over the medium stone is recommended. See Figures 4-4 and 4-5.


OVERFILL TO ALLOW FOR SETTLEMENT
4" TO 6"
SUITABLE PERVIOUS BARRIER
OPENINGS AT JOINTS: 1/8" TO 1/4"
JOINT COVERING
12"
2" MIN.
5" ±
6" MIN.
BACKFILL (EARTH)
LONGITUDINAL SECTION
GRAVEL OR BROKEN STONE
12" TO 36"
CROSS SECTION
LATERAL OF DRAIN TILE (SHOWN) OPEN JOINTED SEWER PIPE OR PERFORATED PIPE
CNE-034

NOTE: DRAIN TILE LAID WITH JOINTS OPENED FROM 1/8 TO 1/4 INCH. SPECIAL COLLARS MAY BE USED IF DESIRED.

Figure 4-3. Typical Layout of Subsurface Tile System

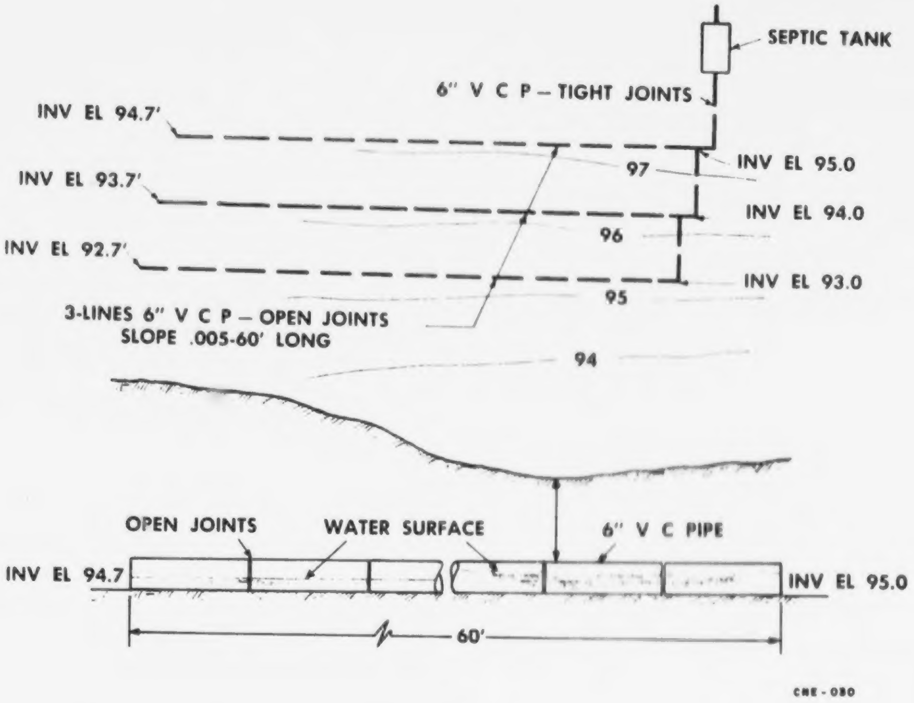

SEPTIC TANK
6" V C P – TIGHT JOINTS
INV EL 94.7'
INV EL 95.0
97
INV EL 93.7'
INV EL 94.0
96
INV EL 92.7'
INV EL 93.0
95
3-LINES 6" V C P – OPEN JOINTS
SLOPE .005-60' LONG
94
OPEN JOINTS
WATER SURFACE
6" V C PIPE
INV EL 94.7
INV EL 95.0
60'
CHE-080

Figure 4-4. Layout of Tile Field on Sloping Ground

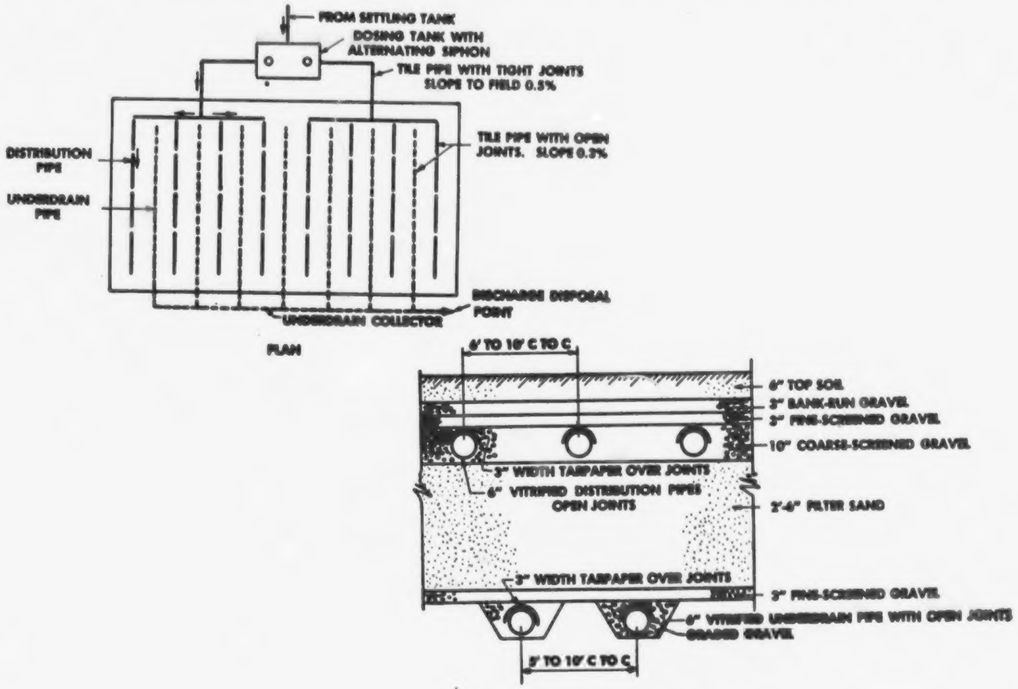

FROM SETTLING TANK
DOSING TANK WITH ALTERNATING SIPHON
TILE PIPE WITH TIGHT JOINTS SLOPE TO FIELD 0.5%
DISTRIBUTION PIPE
UNDERDRAIN PIPE
TILE PIPE WITH OPEN JOINTS. SLOPE 0.3%
DISCHARGE DISPOSAL POINT
UNDERDRAIN COLLECTOR
PLAN
6' TO 10' C TO C
6" TOP SOIL
3" BANK-RUN GRAVEL
3" FINE-SCREENED GRAVEL
10" COARSE-SCREENED GRAVEL
3" WIDTH TARPAPER OVER JOINTS
6" VITRIFIED DISTRIBUTION PIPES OPEN JOINTS
2'-6" FILTER SAND
3" WIDTH TARPAPER OVER JOINTS
3" FINE-SCREENED GRAVEL
6" VITRIFIED UNDERDRAIN PIPE WITH OPEN JOINTS
GRADED GRAVEL
5' TO 10' C TO C

Figure 4-5. Plan and Section of Subsurface Sand Filter Bed

Method Used to Protect Septic Tanks and Tile Fields. Once a septic tank and tile field is constructed all traffic must be excluded by fencing or posting to prevent crushing the septic tank and tile. Planting shrubs or trees over the tank and field is not good practice since the roots tend to clog the tank and tile lines; grass over the lines assists in removing the moisture and keeping the soil open.

INSPECTION. Inspection of the field distribution boxes should be made at frequent intervals. If any portion of the title field is not taking its share of effluent, appropriate adjustments should be made. If it appears that the tile line may be clogged or if effluent is coming to the tile field ground surface the lines should be excavated to determine the reason for failure or clogging. Necessary corrective action should be taken.

Dosing Siphon. The dosing siphon is a mechanical device that transfers wastewater. Dosing siphons may be installed in a dosing tank between a septic tank and tile field. The dosing tank fills to a predetermined level; then the dosing siphon automatically siphons the water out.

Operation of Dosing Siphons. Intermittent dosing of the tile filed is provided by a dosing tank from which fluids are automatically siphoned. A siphon is shown in Figure 4-6 and 4-7. Water will be standing in both the main trap and the blowoff trap. As the liquid runs into the dosing tanks the level rises, covering the open end of the siphon vent. Then, as the water level rises, air is compressed under the bell. The water level is depressed both in the discharge line and the blowoff trap. This continues until the water level is at the maximum discharge line of the tank, while at the same time the water under the bell is near the upper end of the discharge pipe. The water level is at the bottom of both blowoff and discharge line traps. Discharge is now ready and a slight increase of head in the tank causes the water level at the bottom of the blowoff trap to be depressed sufficiently to allow the air pressure to be released with considerable violence up the vent pipe. This sudden release allows water to rush into the discharge pipe. The momentum causes discharge through the siphon and into the distribution system, and the tank then empties. Emptying continues until the water level in the tank is below the elbow of the siphon vent. This permits air to enter the bell, relieves the vacuum, and stops the discharge. Water has also been running through the blowoff trap so it will be filled when the siphon stops.

Maintenance Procedures

Periodic inspection is necessary to prevent health hazards and nuisance. Inspections should be performed at periods of high flow and as frequently as required by tank size and population load, but at least every six months to determine that.

1. Tank inlet and outlet are free from clogging; accumulated material should be immediately removed and disposed of by burying.

2. Depth of scum is such that scum is not passing out with the effluent, and sludge and scum accumulation does not exceed one-fourth of tank capacity.

3. Effluent passing to subsurface disposal is relatively free from suspended solids to avoid clogging of subsurface pipelines and filter beds. The quantity can be determined by the Imhoff Cone Test; more than one milliliter of settleable solids per liter of effluent should be considered excessive.

4. Adjacent facilities such as dosing siphons, distribution boxes, and tile fields are working properly.

Separating sludge and scum from the liquid in septic tanks is difficult; for small tanks they are customarily mixed, the entire contents being removed when cleaning. The material removed contains fresh or partially digested wastewater solids which must be disposed of without endangering public health. Disposal through manholes in the nearest wastewater system as approved by local authorities or burial in shallow furrows on open land is recommended. A diaphragm type sludge pump is best suited for removing the tank contents which should be transported in a water tight closed container.

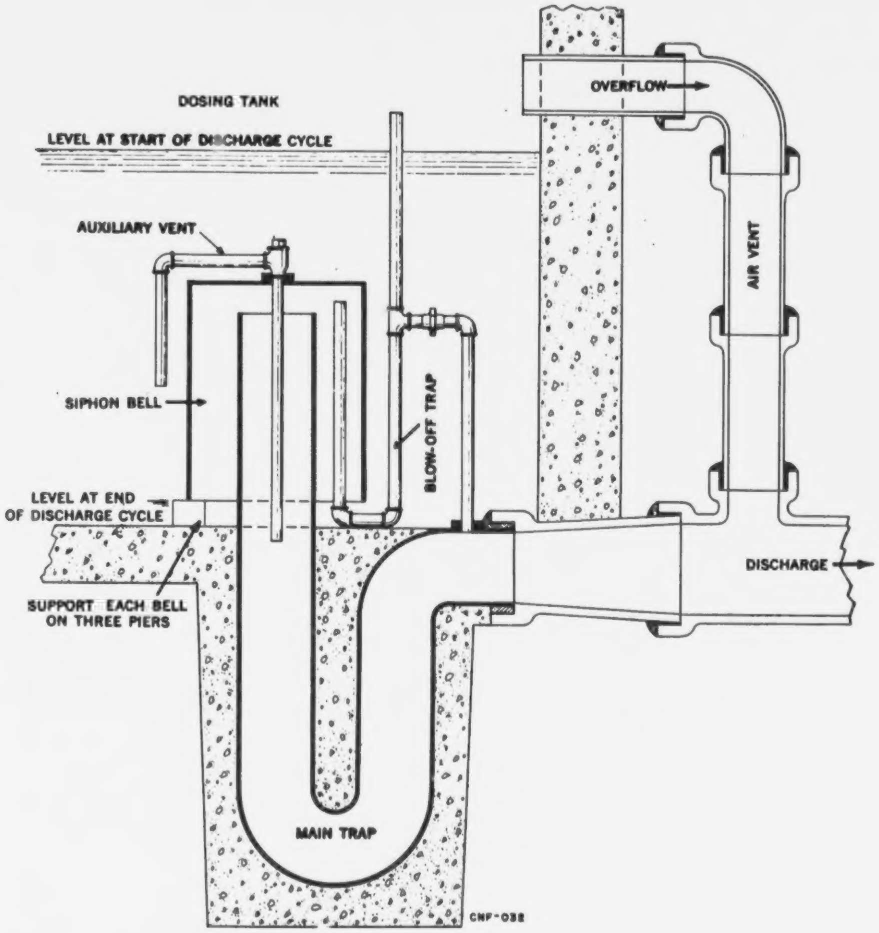

DOSING TANK
LEVEL AT START OF DISCHARGE CYCLE
AUXILIARY VENT
SIPHON BELL
LEVEL AT END OF DISCHARGE CYCLE
SUPPORT EACH BELL ON THREE PIERS
BLOW-OFF TRAP
OVERFLOW
AIR VENT
DISCHARGE
MAIN TRAP
CNF-032

Figure 4-6. Cross Section of a Dosing Siphon

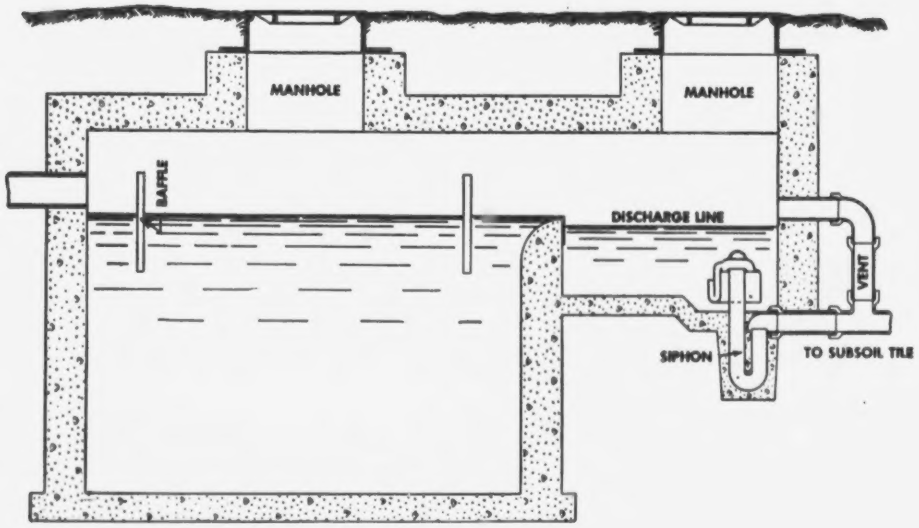

MANHOLE
MANHOLE
BAFFLE
DISCHARGE LINE
VENT
SIPHON
TO SUBSOIL TILE

Figure 4-7. Septic Tank with Dosing Siphon

Contents and effluents of septic tanks are characteristically odorous and offensive. Addition of lime, chlorine, or any other chemical or proprietary compounds is of questionable value and is not recommended. The most effective means of keeping tanks working properly is through periodic removal of sludge and scum.

Records Kept on Septic Tanks and Leaching Fields.

Records should be kept of each septic tank and disposal field inspection. These should include data of inspection, sludge and scum depth, conditions found, and corrective action taken.

EXERCISE IV-4-4a

PART 1

INSTRUCTIONS

Study the illustration of the septic tank in Figure 4-8 below and place the appropriate letter from the list of components in the circles provided.

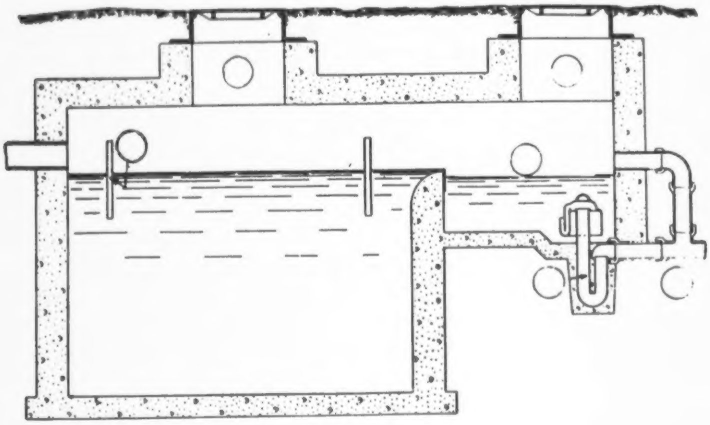


Figure 4-8. Septic Tank

a. Manhole
b. discharge line
c. Siphon
d. To subsoil tile

e. vent
f. baffle
g. manhole
h. dosing siphon

PART 2

INSTRUCTIONS

Use SW J3ABR56631 000-IV-4 to complete the following statements.

1. The minimum size for septic tanks is ______________________________.

2. Septic tanks should have capacity for at least how many hours of detention time?

____

3. Explain the operation of a septic tank. ______________________________

____

____

4. When and how often should inspections be made on the septic tank system? __________

____

5. What type of sludge pump is best suited for removing the septic tank contents?

____

6. What five conditions are important for proper functioning of tile fields?

   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________
   e. ______________________________

7. The layout of the piping system depends on? ______________________________

____

8. What three methods are used for protecting a tile field?

   a. ______________________________
   b. ______________________________
   c. ______________________________

9. Inspection of the field distribution boxes should be made at? ______________

____

10. What is a dosing siphon? ______________________________

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

To improve living conditions and prevent disease, human waste must be disposed of in a sanitary manner. At semi-permanent and permanent installations wastewater must be disposed of in a manner acceptable to sanitary requirements. Small installations use septic tanks. This will improve living conditions and prevent disease.

REFERENCE

Manual of Instruction for Wastewater Treatment Plant Operators, Vol. I.

3770th Technical Training Group
Sheppard Air Force Base, Texas

SW J3ABR56631 000-IV-5

OPERATION AND MAINTENANCE OF PRETREATMENT UNITS

OBJECTIVE

Given information pertaining to pretreatment units and processes, match the terms and phrases to each type of processing unit. Ten of the fifteen must be correct.

INTRODUCTION

A collection system is made up of many miles of pipe below the surface which we cannot see. Its purpose is to collect the wastewater and move it through the underground system by gravity flow to your wastewater treatment plant. The organic materials and the inorganic materials commonly found in wastewater are sometimes treated before they reach your treatment plant. These subjects will be covered under the following areas.

INFORMATION

Definition of Pretreatment

For this course our definition of pretreatment will be any treatment the wastewater receives before it reaches the treatment plant.

Purpose of Pretreatment

The purpose of pretreatment is to remove substances which will harm the treatment plant or the collection system. The transportation of the wastewater is also considered part of the pretreatment process. The major compnents of pretreatment are oil separators and grease traps, the wastewater collection system, and lift stations with screens.

Grease Traps/Oil Separators

Large concrete grease traps outside dining facilities are cleaned by wastewater personnel. Solids must be removed during weekly cleaning to prevent them from decomposing and becoming putrid. Burn or bury grease removed from grease traps.

Oil separators are sometimes called oil traps. They are installed in all drains from flight lines and motor pools and other activities discharging oily wastes. These units must be cleaned regularly. If gasoline, oil or grease are entering the sewers, their source must be traced and corrective action must be taken at that time. To avoid fire and explosion the discharge of gasoline, kerosene and other volatile liquids into sewers will be prohibited.

Make-up of Wastewater Collection Systems

By the make-up of collection systems we are referring to all pipes or conduits which are used to move wastewater. Since these lines have special purposes we are going to classify them according to the uses to which they are put. The first one we will discuss is sanitary sewers. They are made up of a series of pipes designed to carry sanitary or domestic wastewater only. The second one we are going to discuss is storm sewers which are designed to carry storm run off only. And the last collection system is combined sewers. They are designed to carrry both sanitary wastewater and storm runoff.

Common Troubles of Collection Systems

A common problem with the collection system is breaks or leaks which will cause infiltration. This is most likely to occur at joints or manholes. Another problem is accumulations of grease and trash which can plug the line. Roots will be attracted to the moisture in the line. Once they get into the sewer line they can plug it up. A large amount of grit and sand can also reduce the flow in the line and cause flooding. misalignment of the sewer line can cause pockets of water or breaks in the line. If there are pockets of water or breaks the wastewater may turn septic and smell. Structural failure of the pipe may be caused by not laying the pipe properly or it being washed-out by heavy rains.

Screens and Lift Stations

SCREENS

In the pretreatment process screens are installed to remove any large floating material. This saves your wastewater plant treatment equipment. It keeps lines from becoming clogged in your treatment plant and from wearing of pump parts. Screens are installed at lift stations which will be our next discussion and will be covered more completely.

NOTE: Read the following for additional information on Collection System, Chapter 2, Sections 1, 2 and 3.

Lift Stations. Lift stations are used where gravity flow is not possible. The pumps used in a lift station must lift wastewater from a low area under ground to a higher point so the waste can start its slow downhill travel again. For this reason the pumps must handle large quantities at low velocities. The pumps must also have large openings to allow large solids to pass through them.

Before you plunge into this subject we would again remind you to be careful of toxic gases. A wastewater lift station is a dangerous place since the equipment is generally located in a dry well or an underground vault where ventilation is not good. See Figures 5-1 and 5-2 for an example of the wet well and dry well parts of a lift station.

Wet Well. The wet well area is structured to contain or hold the incoming liquid until a certain water level is reached. The level of the wastewater in the wet well is maintained using an air bubbler system or ball float. Both these devices activates an electric motor which in time devices the lift pumps.

Dry Well. The dry well provides for easy access to the equipment for inspection and maintenance purposes. A water-tight, air-tight floor or wall keeps this section dry and clean. Most of the controls for lift station operation are contained in the dry well area. Valve controls can be mounted so as to be above the wastewater level or extended into this dry area. Pump shafts and other moving parts are enclosed in full-length housings or protective guards and sheilds.

Building Maintenance. Lift stations are housed in a concrete or brick building. The walls of the building may serve to hold the incoming wastewater. When the depth of wastewater reaches a certain point the pump will automatically come on and pump the level down.

Maintenance on the building can actually be divided into three separate areas: ceilings, upper walls, lower walls and the floor.

The ceiling, upper walls, windows and overhead pipes stay wet all the time from condensation. Wastewater gases create an acid condition in the humidity and this acid eats at the masonry in the building. It corrodes the metal in the pipes and windows.

Proper ventilation helps get rid of the moisture and a good paint job on the pipes and windows helps protect them from deterioration.

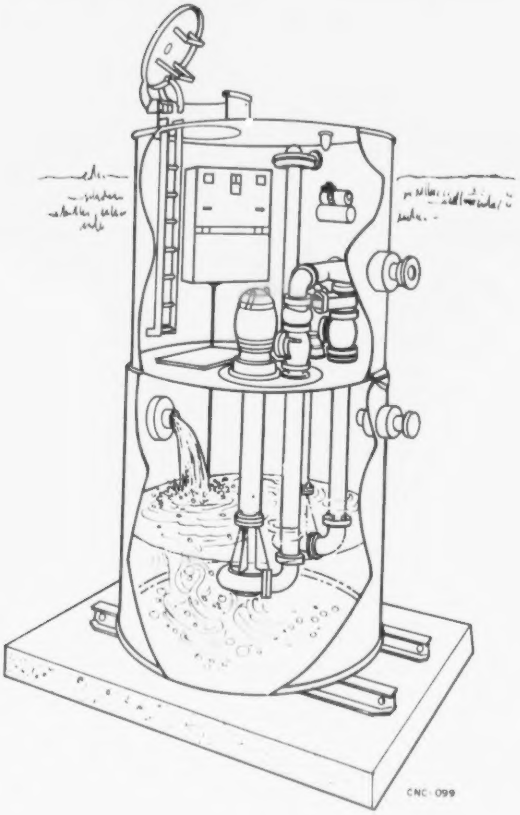


Figure 5-1. Lift Station, Wet Well Attached

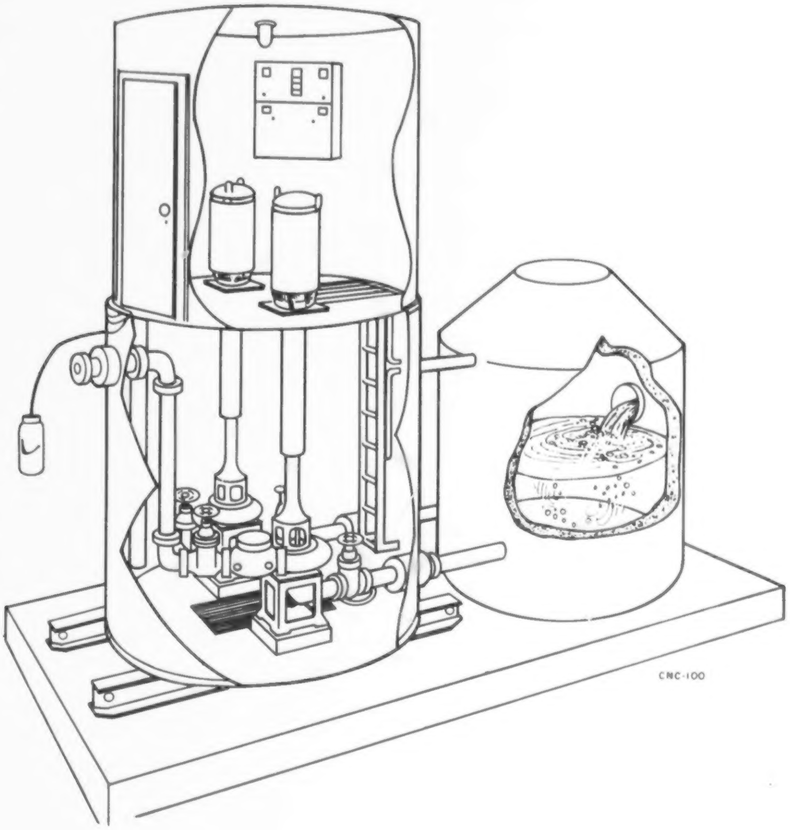


Figure 5-2. Lift Station, Wet Well Separate

The second area of building maintenance is the cleaning of the walls that is below the wastewater level. Thick layers of grease build up on the walls and have to be scraped and hosed down. Accumulation of grease creates nuisance odors and unsightliness.

The third area of building maintenance is the cleaning of the floor. Grit, stones, grease and heavy materials have to be cleaned out. This job is usually done manually as the amount to be hauled out is small.

Pump Maintenance. Pumps used for lifting wastewater are most commonly the centrifugal or ejector types because they are not subject to fouling or blockage by floating debris such as the head of a mop. A submerged type of centrifugal pump is shown in Figure 5-3. If you have to adjust the impeller you should keep in mind that the installation has a thrust adjustment collar. Look at Figure 5-3 and you will see that No. 1 points out a coupling which allows for up or down movement. No. 2 locates the thrust adjustment collar which is raised or lowered to place the impeller at the correct height in the pump body. No. 3 points to the mounting flange which supports the pump column. Note that the intermediate bearing is provided with an oil supply line from under the floor. You should always be sure that the plug or cap is kept on the line to keep dirt from entering it. Make the normal check on electric motors before starting.

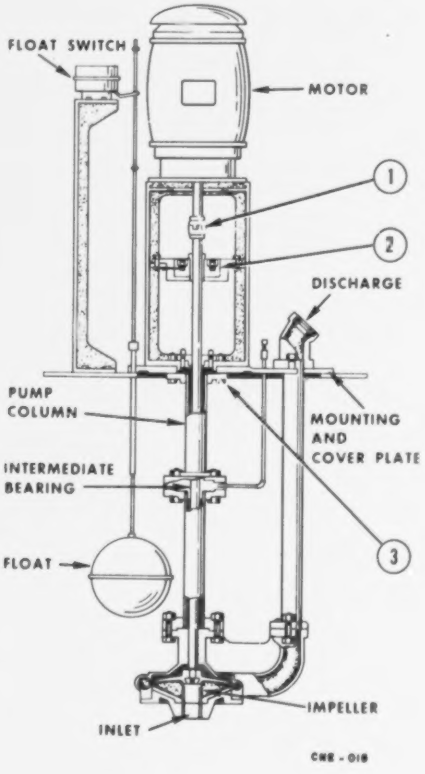


Figure 5-3. Submerged Type Centrifugal Pump

When there are two pumps installed, start the motors to initiate a pumping cycle and make the following checks: Figure 5-4.

(1) Check controls for proper operation and sequencing.

(2) Check fuses or press overload reset button on the circuit breaker. If the motor fails to start, determine the possible cause of the overload.

(3) Note any unusual noises or vibrations.

(4) Insure the motor mounts and frames are secure, bearings are greased and motor temperatures are not hot. The motor should not be so hot that you cannot hold your hand on it.

(5) Check for smoke or for smell of burned insulation.

Cleaning the pump. Close the necessary valves to shut off liquids from both sides of the pump. Turn off the motor switch so it cannot start. Remove the covers of clean-out holes and remove all solids. When work on the pump is completed, turn the motor supply switch on so that the pump can operate. Pump down the well and wash down the sides and pipes as required. Floats, rods, chains and pipes in the well must also be washed.

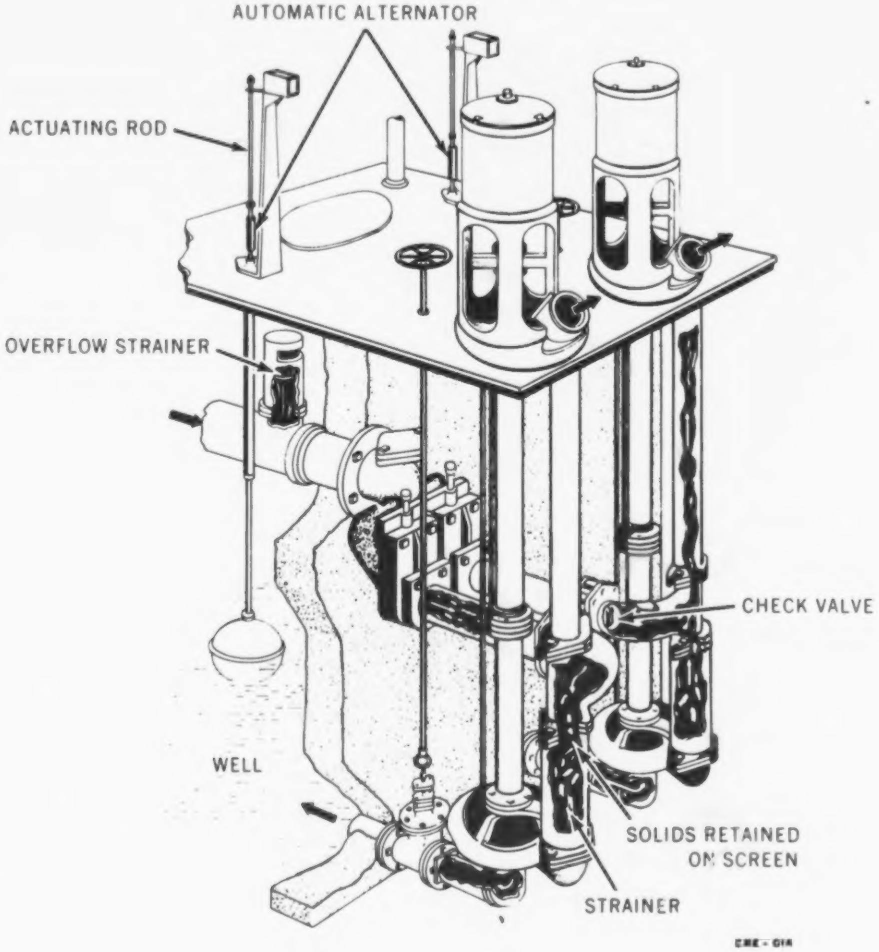

AUTOMATIC ALTERNATOR
ACTUATING ROD
OVERFLOW STRAINER
CHECK VALVE
WELL
SOLIDS RETAINED ON SCREEN
STRAINER

Figure 5-4

EXERCISE IV-5-5a

PART 1

INSTRUCTIONS

Use SW J3ABR56631 000-IV-5 to complete the following questions.

1. How often should solids be removed from grease traps? ____________________

____

2. Where are oil separators installed on an Air Force base? ____________________

____

3. What is a hazard associated with oil separators? ____________________

____

4. What is the purpose of a screen at a wastewater lift station? ____________________

____

5. Where are wastewater lift stations installed? ____________________

____

6. What is a wet well? ____________________

7. What is a danger of a dry well? ____________________

8. What do wastewater gases do when they come in contact with condensation over a long period of time? ____________________

____

9. Accumulation of grease on the walls of a lift station creates what? ____________________

____

10. What two types of pumps are not subject to fouling or blockage by floating debris?

____

PART 2

INSTRUCTIONS

Use SW J3ABR56631 000-IV-5 to complete the following phrases.

1. ____________________ are used where gravity flow is not possible.

2. The pumps must also have ________________ ________________ to allow large solids to pass through them.

3. A wastewater lift station can be a dangerous place if proper ________________ is not provided.

4. Wastewater lift stations are housed in a ________________ or ________________ building.

5. Maintenance on the building can be divided into three separate areas, these are

   ______________, ______________, and ____________________.

6. Accumulation of ____________________________ creates nuisance odors and unsightliness.

7. Pumps for lifting wastewater are most commonly ________________________ or

   ____________________ types.

8. When initiating a pumping cycle make a check for any noises or ________________.

9. Check also for smoke or smell of ____________________ ________________________.

10. When the work is completed, turn the motor supply ____________________________ on, so that the pump can operate.

PART 3

INSTRUCTIONS

Use your SW J3ABR56631 000-IV-5 to match the following set of pretreatment processes.

1. ______ A device for separation of grease from wastewater by flotation so that it can be removed from the surface, located outside of dining facilities.

2. ______ A device for separation of oil from wastewater by flotation so that it can be removed from the surface, located on flight lines.

3. ______ Are installed to remove any large floating material.

4. ______ All pipes or conduits which are used to carry wastewater.

5. ______ These systems which are designed to carry storm water only.

a. collection system

b. screens

c. oil separators

d. grease traps

e. storm sewers

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review s[illegible] of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

To improve living conditions and prevent disease, human waste must be disposed of in a sanitary manner. The need for grease traps, oil separators, collection systems, and screens are important for proper pretreatment of wastewater before it reaches the plant. Maintenance of sewage treatment equipment is not an everyday job; however, inspection of the equipment is a constant job. Good maintenance and regular inspections prevent lift stations from becoming a worn-out health hazard.

REFERENCE

AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

3770th Technical Training Group
Sheppard Air Force Base, Texas

SW J3ABR56631 000-IV-G

OPERATION AND MAINTENANCE OF PRELIMINARY TREATMENT UNITS

OBJECTIVES

Demonstrate a knowledge of the purpose of preliminary treatment units and subsystems by making written response to questions that pertain to preliminary wastewater treatment. Seven of the ten responses must be correct.

Using information and assistance from your instructor, list the required maintenance for screens, grit removers, shredders, and preaerator, according to AFM 91-32. Six of ten must be correct.

INTRODUCTION

When you graduate from this course you will be going to a base and perhaps be operating a wastewater treatment plant. You must be able to recognize the equipment used in this plant and know how it operates. This subject will be covered under the following topics.

- Definition of preliminary treatment
- Screens
- Grit chamber
- Shredders
- Preaeration
- Measuring devices

INFORMATION

Definition of Preliminary Treatment: Preliminary treatment is the first treatment the wastewater receives as it enters the plant.

Screens

The screening of wastewater is a mechanical operation for removing the large particles of floating or suspended matter. The process is usually done in two parts: coarse screening and fine screening. Coarse screens are used for removing floating objects and are the first step in the treatment of the wastewater. Fine screens are used for removing floating grease. Where any type of mechanical equipment is a part of the treatment process you will have a build up of solids on your equipment. These solids are a hazard to the wastewater plant operation.

Screens are used to protect the pumps and to remove floating materials that would form a heavy floatage in the settling tanks. They are made of steel bars spaced 1/2 inch or more apart. The bars form a grid that is placed at an angle to the direction of flow in the influent channel. The screens are cleaned manually or mechanically. In manual cleaning the screen chamber is flushed frequently with a heavy stream of water to remove grease and material collected in front of and under the screen. A long-handled rake is used to pull the screenings to the top of the screen and deposit them on a draining platform. The mechanically cleaned screen has a built-in rake. It operates by either a float switch which activates the rake when there is a loss of head or pressure through the screen, or by an electric motor with gear reducers.

Fine screens with 1/4 inch openings or smaller are sometimes used to remove an additional quantity of suspended solids before further treatment. They are commonly of the rotating drum or rotating disk type. Cleaning is accomplished by scrubbing or brushing, preferably with water under pressure from a hose. When the screen becomes clogged with grease it can be cleaned with kerosene. See Figure 6-1, Mechanically Cleaned Bar Screen.

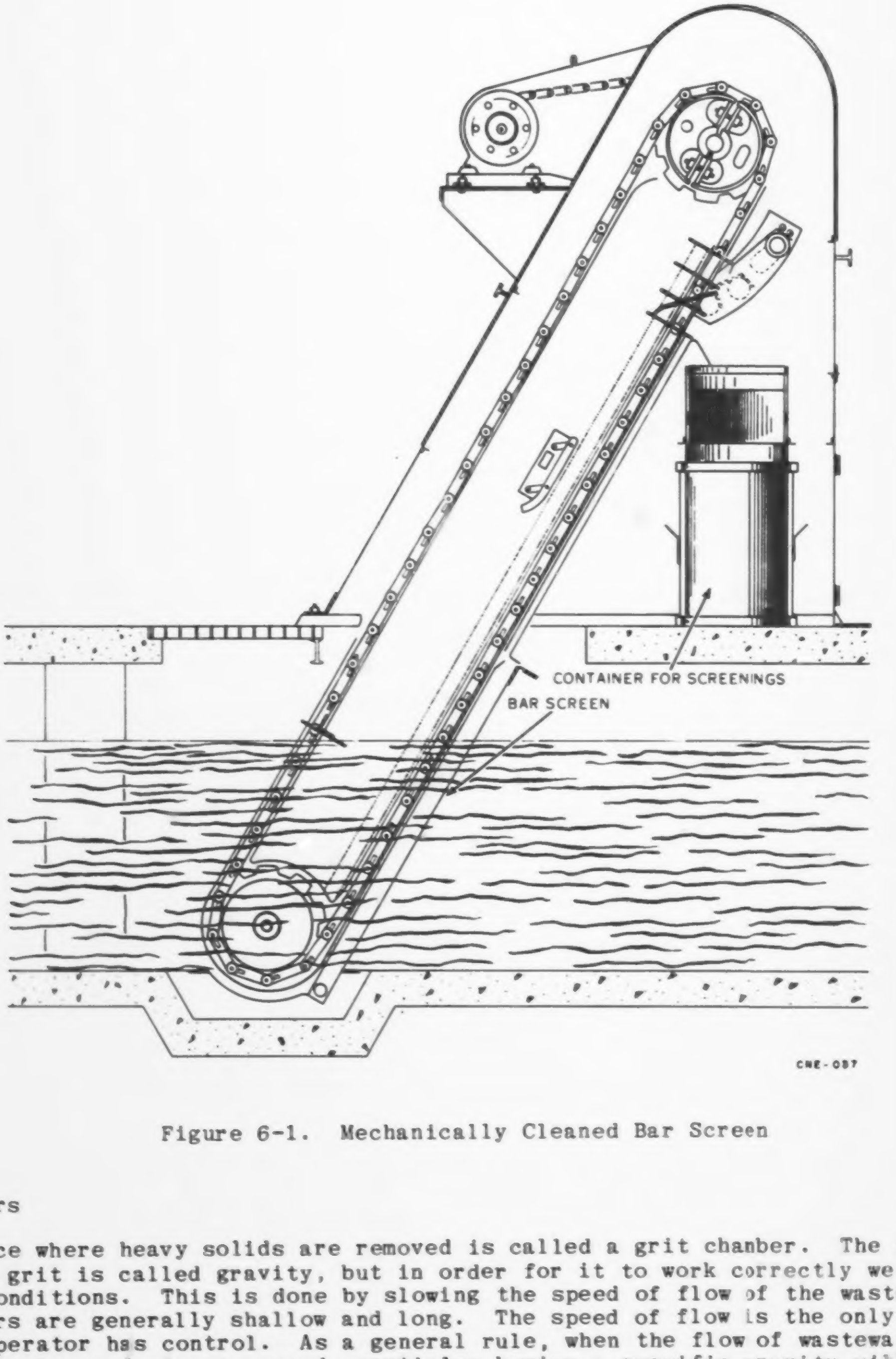


Figure 6-1. Mechanically Cleaned Bar Screen

Grit Removers

The place where heavy solids are removed is called a grit chanber. The force which removes the grit is called gravity, but in order for it to work correctly we must supply the right conditions. This is done by slowing the speed of flow of the wastewater. Grit chambers are generally shallow and long. The speed of flow is the only thing over which the operator has control. As a general rule, when the flow of wastewater is slowed to about one foot per second, particles having a specific gravity will settle to the bottom. The most effective flow will vary from plant to plant. Removing inorganic matter from the grit chamber by mechanical process is done by the deposit at the foot of an incline, moving it up by scrapers or a screw conveyor. See Figure 6-2. The grit should be disposed of in a sanitary landfill.

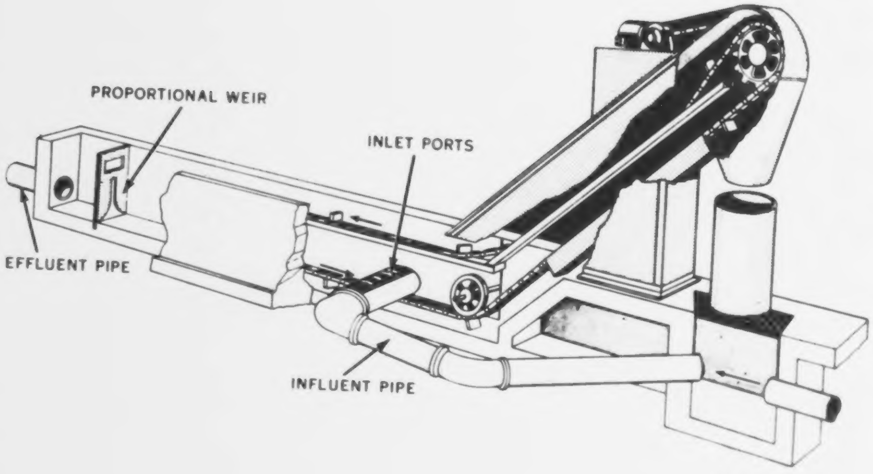


Figure 6-2. Grit Remover

Shredders

GRINDER. The first type of shredder we will cover in this unit is a grinder. A mechanical grinder uses a swing hammer to grind solids to a pulp while rocks, iron, and other hard materials are put into a trap. Some shredders use a rotor which has tool-steel teeth that shred the material as it passes between them. The ground material is then washed back into the raw wastewater at a point past the screen. The second type of shredder is the comminutor. It is a vertical, slotted drum equipped with cutting knives which are turned by an electric motor. The wastewater flowing through the slotted drums forces coarse solids against the knives until they are reduced to pieces small enough to pass through the slots.

COMMINUTORS. These are vertical, slotted drums equipped with cutting knives revolved by an electric motor. The wastewater flowing through the slotted drums forces coarse solids against the knives until they are cut into small pieces. Another type of comminutor, a submerged screen shredder, is semicylindrical in shape and has cutters operating within a fixed semicircular screen grid. It is usually installed in conjunction with a bar screen which may be put in service when the comminutor is shut down for repair. See Figure 6-3, Cutaway View of Comminutor.

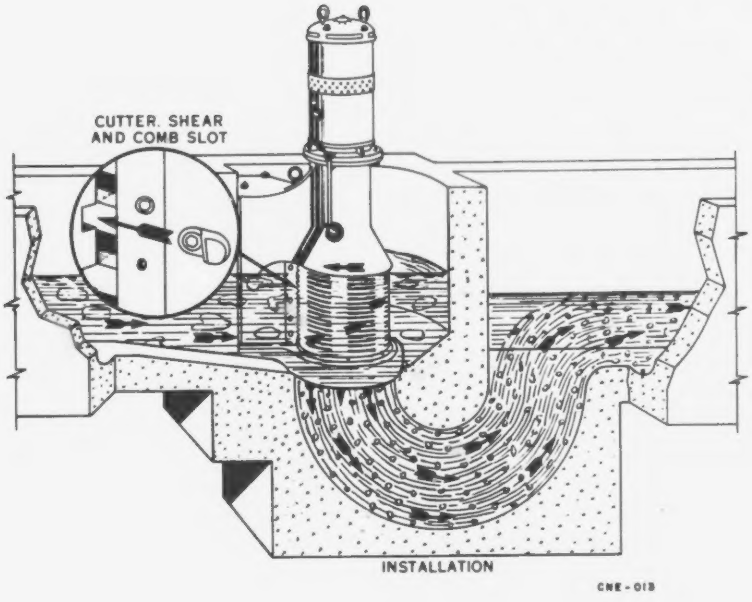


Figure 6-3. Cutaway View of Comminutor

Preaeration

Preaeration is a method of agitating or stirring new wastewater by diffusing air through it. A preaeration period of from one to three hours is needed to produce good results. Operation must be going all the time in your tank to prevent the deposit of organic solids and clogging of your air lines. The depth of the grit in your tank bottom must be determined weekly. When the depth of the grit is 4 to 6 inches, the tank should be emptied and the grit shoveled out to prevent any organic solids mixed with it from becoming septic. For this aeration process you need a separate tank in your plant located after the grit chamber, but before your primary treament tanks.

GREASE REMOVAL. Preaeration is a method of agitating or stirring new wastewater by diffusing air through it. It was installed initially at some installations for grease removal on the principle that the emulsified particles will cling to the air bubbles and rise to the surface. Grease forms a mat that can be skimmed off. A preaeration period of from one to three hours is necessary to produce worthwhile results. Only in extreme cases is this economically feasible. The use of existing preaeration tanks is justified if needed to keep wastewater fresh by resupplying the oxygen as it passes through primary tanks, for reducing odors, and for increasing the effectiveness of secondary treatment. They may also be used as grit chambers.

VACUUM FLOTATION. Vacuum flotation as a method of grease removal has the same disadvantages or limitations as preaeration. The same principle of aeration is used but with the addition of suction, supplied by a small vacuum pump, to carry solids to the surface. This process removes a little more grease than primary settling alone. Vacuum flotation, however, is sometimes used for primary settling to remove setteable solids along with grease. A detention period of 15 to 20 minutes keeps wastewater fresh. They may also be used as grit chambers. See Figure 6-4, View of Vacuum Flotation.

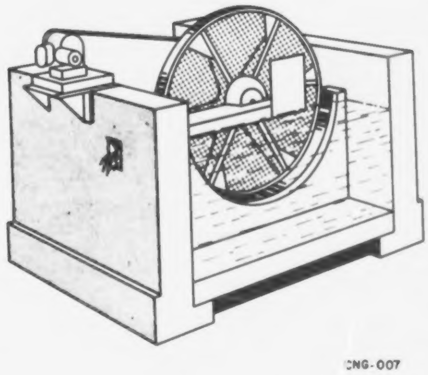


Figure 6-4. View of Vacuum Flotation

Measuring Devices

Wastewater treatment plants should have metering equipment to let plant operators measure and record flow through their plants. This information is needed for you to know how well your plant is working. In some plants you may need to add meters to measure recirculation, chemical feeding and return activated sludge. The choice of measuring devices will depend on your plant, the treatment process utilized and the required degree of accuracy.

PARSHALL FLUME. The Parshall flume may be used to measure wastewater flow in open channels. The flume must be kept free from trash which may catch in the flow channel. Any trash that is found in the still well should be removed.

VENTURI FLUME. The Venturi flume is used for measuring flows in sewers because it does not require special structures. Very little operation or maintenance is needed, but you must make sure passages of the flume are kept clear from slime and trash to insure that it operates right. For the secondary element, a single float-actuated recorder may be used.

EXERCISE IV-6-6a

PART 1

INSTRUCTIONS

Use SW J3ABR56631 000-IV-6 to complete the following questions.

1. The two types of bar screens are ____________________ and ____________________.

2. ____________________ screens are used primarily for removing floating objects.

3. ____________________ screens are used for removing floating grease.

4. A ____________________ ____________________ uses a swing hammer to grind solids to a pulp.

5. A ____________________ is a vertical, slotted drum equipped with cutting knives revolved by an electric motor.

6. The place where heavy solids are removed is called a ____________________

____________________________________.

7. Grit chambers are generally ________________ and ____________________.

8. The flow of wastewater through a grit chamber is about ____________________

__________ ______ __________ ____________.

9. The grit should be disposed of in a ______________ ________________.

10. ____________________ is a method of agitating or stirring new wastewater by diffusing air through it.

11. Wastewater treatment plant should have metering equipment to let plant operators ________________ and ________________ flow through their plants.

12. The ______________ ______________ may be used to measure wastewater flow in open channels.

13. What is the definition of preliminary treatment? ____________________

____

PART 2

INSTRUCTIONS

Use SW J3ABR56631 000-IV-6 to answer the following statements.

1. What are screens used for in wastewater treatment? ________________

____

2. What are the two types of screens? ____________________________

____

3. What is the purpose of a shredder? ____________________________

____

4. What is the purpose of a grit chamber? __________________________

____

5. How much time should be allowed for the preaeration process? ____________

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

Use AFM 91-32 for the maintenance of Preliminary Treatment Units.

Read Chapter 4, Section 2, Operation and Maintenance, Para. 4.2.1 to 4.2.8; Chapter 3, Section 1, General; Section 2, Methods of Flow Measurement; Section 3, Operation; para. 3.1.1 to 3.1.2, 3.2.1 to 3.2.4, and 3.3.1.

EXERCISE IV-6-6b

INSTRUCTION

Using AFM 91-32, Chapters 3 and 4 to answer the following questions on maintenance of Preliminary Treatment Units.

1. Improper storage and handling of screenings provides a source of food for pests.

   What action must be taken? ______________________________

   ____

2. Bar screen not raked properly or not as often as needed, (mechanical) ______________________________.

3. Comminutor or barminutor not operating, likely causes -

   a. ______________________________.

   b. ______________________________.

   c. ______________________________.

4. Improper shredding. Unusual vibration and noise from the comminutor or barminutor, likely causes -

   ____

   ______________________________.

5. The maintenance of the hand raked bar screens is the same as for the racks, except

   for ______________________________

   ____

   ____

   ______________________________.

6. The maintenance on comminutors and barminutors most often required for good

   operation is ______________________________

   ____

   ______________________________.

7. Controlled grit removal channels may be cleaned by ______________________________

____.

8. Maintenance of aerated grit removal units includes ______________________________

____

____.

9. A float well connecting pipe valve should remain wide open at all times, except for

____

____

10. Maintenance on a venturi meter must be in accordance with ______________________

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

In this study guide/workbook you have read about preliminary treatment and subsystems. The treatments being screens, shredders, grit chambers, preaerators and measuring devices.

REFERENCE

AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

OPERATION AND MAINTENANCE OF PRIMARY TREATMENT UNITS

OBJECTIVES

While visiting a municipal wastewater plant, observe the operation of the plant and equipment. Use a schematic to trace the flow through the system and a checklist to list the maintenance safety items with no more than three instructor assists.

Using given information and a sampling device, and working as a team, collect a wastewater and a sludge sample from various sampling points within the plant, with no more than two instructor assists.

Following written instructions, identify the operation of primary wastewater treatment units by making written responses to questions according to AFM 91-32. Thirty of the forty-four answers must be correct.

Following written instruction, list the maintenance practices of primary wastewater treatment units by making written responses to questions according to AFM 91-32. Eight of twelve responses must be correct.

INTRODUCTION

When you graduate and go to another base, you may be required to operate a wastewater plant. This study guide/workbook will aid you in learning the fundamentals of primary waste treatment. The treatment process begins with the removal of sand, grit and large floating solid materials. This removal of solids is known as preliminary treatment. The next stage of treatment is called primary treatment which further processes the wastewater to a point where it can be disposed of properly.

Waste treatment information will be covered under the following topics:

- Definition of primary treatment
- Imhoff tanks
- Primary settling tanks
- Separate digester and components
- Sludge drying
- Sludge disposal

INSTRUCTIONS

While on the field trip to the municipal wastewater plant and lift station observe the plant system and components. The instructor will discuss the plant system and issue a progress check to you consisting of a diagram of the lift station and plant. Complete the diagram during the field trip, then turn in the progress check to your instructor when it's completed.

INFORMATION

WASTEWATER AND SLUDGE SAMPLING

Types of Sampling

No lab test can give you a true idea of how your plant is doing unless you take your samples correctly. Haste in getting your sample, or getting it ready for testing, can offset the accuracy of the tests made in the lab. The two types of samples that will be used in wastewater sampling are grab and composite. A grab sample represents the conditions at a particular point in time. A composite sample is a series of grab samples which represent conditions over a set period of time. A few factors which should be considered in collecting a sample are:

What kind of lab examinations are to be made.

The use to be made of the results of the tests or analyses.

The nature of the material to be sampled and the time lapse over the period of sampling.

The change in the flow over the sampling period.

Methods of Collection

The sample should always be collected in a glass or plastic bottle. The volume of sample obtained should be sufficient to perform all of the required analyses, with an additional amount obtained for repeating any doubtful analyses. it is seldom safe to rely on a single sample or a grab sample. There is no ideal time for collecting a sample. A sample collected at one time might give you different results than one taken earlier or later. One way to correct this problem is to take a composite sample. Always keep samples in a cool place. There are two methods of collecting samples; manual and automatic. With the manual method you as an operator have a metal or plastic bottle on a wooden pole or a string. You drop the sampler just below the surface and obtain your sample. The automatic sampler is plugged into an outlet, the collection device is dropped into the wastewater and weighed down. At intervals the sampler will come on and collect the wastewater through a tube and put the sample into a plastic container. After the time has expired for collection of the samples the automatic sampler shuts off.

Sampling Points

In a treatment plant the two areas that you will be taking samples from are the wastewater and the sludges. The location of sampling points within a treatment plant will vary with the design of the facility and sampling procedures must be adapted accordingly. To collect a good representative sample certain procedures must be followed.

1. The sample should be taken from a place where the wastewater is well mixed.

2. When the sample is taken from the center of the channel the velocity of the wastewater should be high enough to keep the solids in suspension.

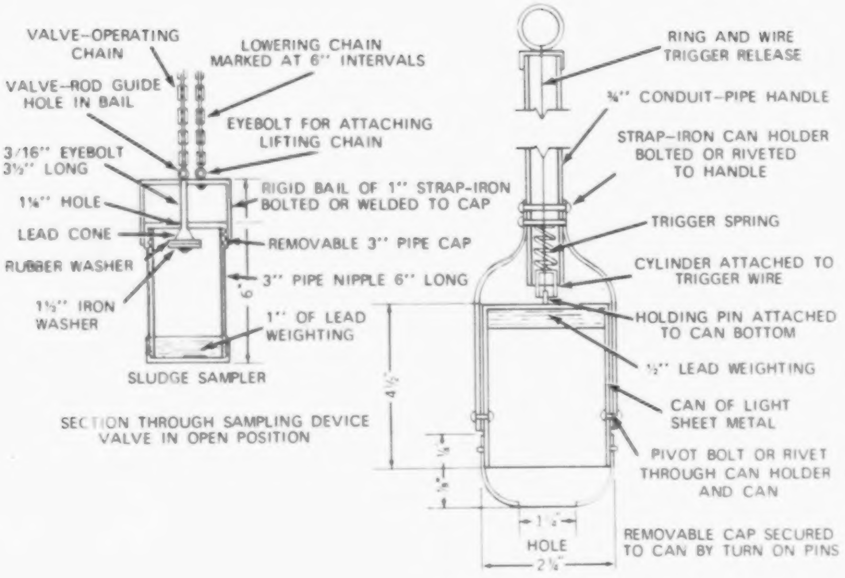
3. The sample should be taken slightly below the surface of the wastewater to avoid an excess of floating matter. you should also be careful not to collect solids which may have settled to the bottom of the channel.

4. You should not include particles larger than 1/4 inch in diameter in the sample.

5. When sampling sludges, a sample should be taken from several different depths to see how the entire digestor is working.

6. The sampling points should be readily accessible, proper sampling equipment should be available, and adequate safety precautions must be observed.

A typical sampler for wastewater and for sludge can be seen in figure 7-16.


VALVE-OPERATING CHAIN
LOWERING CHAIN MARKED AT 6" INTERVALS
VALVE-ROD GUIDE HOLE IN BAIL
EYEBOLT FOR ATTACHING LIFTING CHAIN
3/16" EYEBOLT 3½" LONG
RIGID BAIL OF 1" STRAP-IRON BOLTED OR WELDED TO CAP
1¼" HOLE
LEAD CONE
REMOVABLE 3" PIPE CAP
RUBBER WASHER
3" PIPE NIPPLE 6" LONG
6"
1½" IRON WASHER
1" OF LEAD WEIGHTING
RING AND WIRE TRIGGER RELEASE
¾" CONDUIT-PIPE HANDLE
STRAP-IRON CAN HOLDER BOLTED OR RIVETED TO HANDLE
TRIGGER SPRING
CYLINDER ATTACHED TO TRIGGER WIRE
HOLDING PIN ATTACHED TO CAN BOTTOM
½" LEAD WEIGHTING
4½"
CAN OF LIGHT SHEET METAL
PIVOT BOLT OR RIVET THROUGH CAN HOLDER AND CAN
1¼"
HOLE
2¼"
REMOVABLE CAP SECURED TO CAN BY TURN ON PINS

SLUDGE SAMPLER

SECTION THROUGH SAMPLING DEVICE
VALVE IN OPEN POSITION

SEWAGE EFFLUENT SAMPLER

SECTION THROUGH SAMPLING DEVICE
CAN IN EMPTY (INVERTED) POSITION

Figure 7-16. Samplers Designed for Collecting Wastewater and Sludge

EXERCISE IV-7-7b

INSTRUCTIONS

Using your SW J3ABR56631 000-IV-7, complete the following statements.

1. What is a grab sample? ______________________________

____

2. What is a composite sample? ______________________________

____

3. What are the four factors that should be considered in taking a sample?

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

4. What type of container should the wastewater or sludge sample be collected in?

____

5. What are the two methods of collecting wastewater samples? ______________

____

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

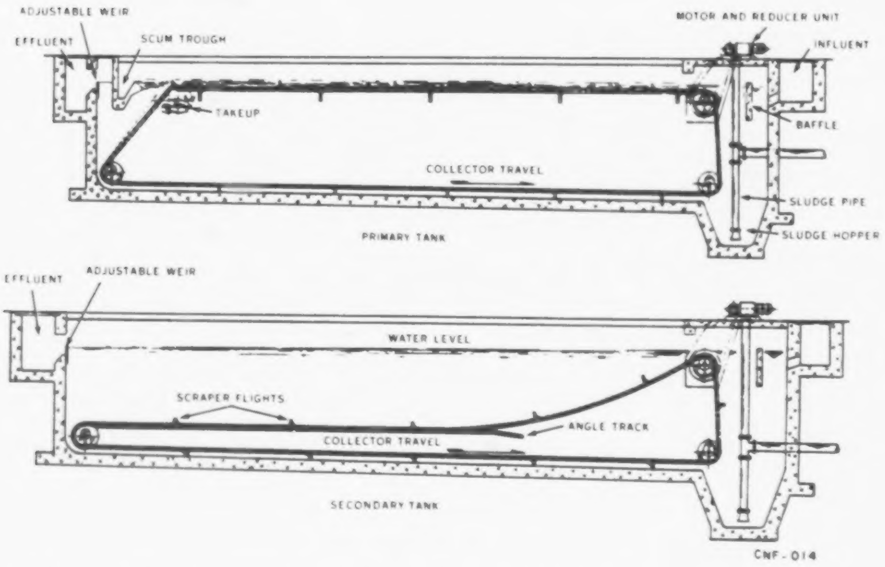

ADJUSTABLE WEIR
EFFLUENT
SCUM TROUGH
MOTOR AND REDUCER UNIT
INFLUENT
TAKEUP
BAFFLE
COLLECTOR TRAVEL
SLUDGE PIPE
SLUDGE HOPPER
PRIMARY TANK
EFFLUENT
ADJUSTABLE WEIR
WATER LEVEL
SCRAPER FLIGHTS
ANGLE TRACK
COLLECTOR TRAVEL
SECONDARY TANK
CNF-014

Figure 7-1. Rectangular Settling Tank and Mechanism

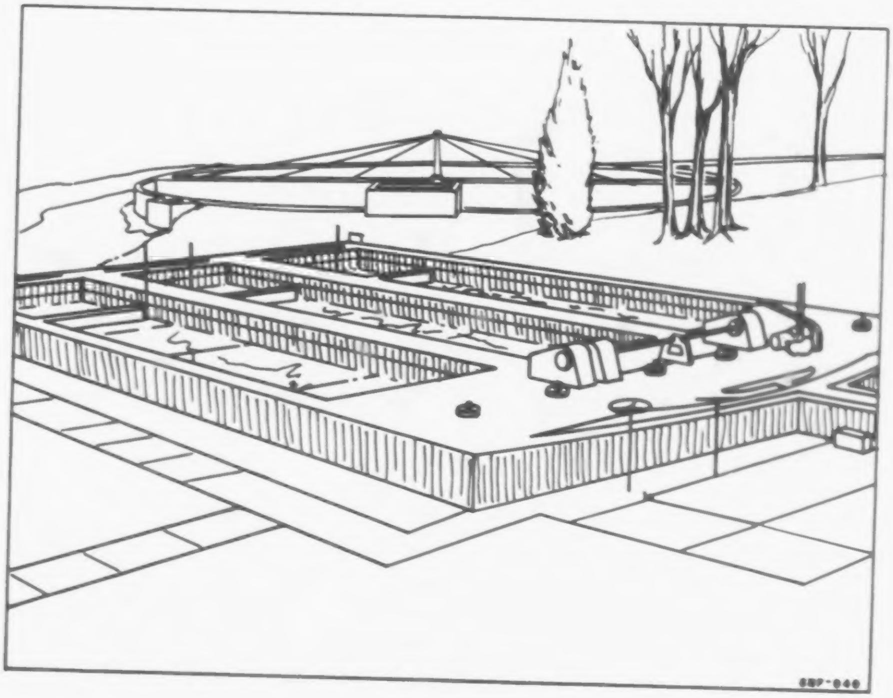


Figure 7-2. Rectangular Tank Showing Skimming Action of Mechanism

OPERATION AND MAINTENANCE OF PRIMARY UNITS

Definition of Primary Treatment

Primary treatment is the removal, treatment and disposal of settleable solids from wastewater.

Primary Settling Tanks

Settling tanks or clarifiers are used to remove the settleable solids from wastewater. The sludge from these tanks is moved to a separate digestion tank or other place of disposal.

There are three types of settling tanks. These are primary tanks which are used for the treatment of raw or screened sewage, intermediate tanks which are used between two stages of biological treatment, and final tanks which are used for the last stage of settling. Two types of sludge removal can be used. Some tanks have a hopper shaped bottom to collect the sludge while others have mechanical collectors. The tanks with mechanical collectors can be rectangular or circular.

RECTANGULAR TYPE. Rectangular type tanks are shown in Figure 7-1. Figure 7-2 is an overhead view of this tank showing the sludge and scum removal equipment. Chain conveyors sweep the sludge particles accumulated on the bottom toward the sludge hoppers at the influent end. On the primary tank the conveyor sweeps the entire surface of the tank forcing the scum directly to the draw-off point in front of the effluent baffle. Sludge hoppers are emptied by gravity or by pumping while the tank remains in operation.

CIRCULAR TYPE. The circular type tank with mechanical sludge collection is illustrated in Figure 7-3. Figure 7-4 is a cut-in view of a circular tank showing the type of sludge collector mechanism. The influent comes through a centrally located, inverted siphon surrounded by a submerged diffuser which introduces the feed quietly and well below the surface, distributing it evenly to all parts of the tank.

HOPPER TYPE. Sludge can be removed from hopper tanks through withdrawal pipes without the necessity of emptying the tanks or interrupting operation. Hoppers, which take the place of sludge collector mechanism, are suitable for smaller installations. Figure 7-5 shows a multiple hopper settling tank.

Detention Time. The normal detention time of primary and secondary settling tanks range from one to two hours for an average daily flow. With activated sludge plant's, primary tanks where it should be 1.5 hours. Too much detention may cause septic wastewater, produce odors, and increase the load on secondary treatment units. Where duplicate units are used long detention times are avoided by removing one or more tanks from service during low flows or by recirculating effluent from the secondary units through the primary tank. When removal of solids by settling tanks is far below normal (45 to 60 percent suspended solids), the cause should be found. Operators should always look for ways to improve operation.

Operation. Good housekeeping at the settling tank is esential to prevent odors, flies, and unsightly appearance. Floating solids passing out with the effluent may clog the filtering equipment and grease may cause ponding of the filter.

Floating Material Removal. Floating material must be removed once each shift or more often if needed. Some mechanical skimmers automatically remove this material to a sump for disposal while other tanks have a manually operated skimming pipe. However, a hand skimming tool should always be used to aid the entrance of skimmings to the pipe or trough. Where skimmings are pumped to the digester, a minimum of wastewater and wash water should go with it to prevent upsetting the digester operation. If a large quantity of fairly dry skimmings tends to upset digestion, they should be collected in a covered can with openings for draining excess water and hauled to a sanitary fill or incinerator. The can must not be placed where the drainage becomes a nuisance. If a fill is not available, skimmings are drawn to a trench and covered with at least 2 feet of earth. A spray of water directed against floating material frequently settles it.

Cleaning Sidewalls. Sidewalls of channels, baffles, weirs, launders, and tanks are kept clean of grease and other solids by hosing, scraping, or brushing once each day or more often if needed.

Dead ends and corners are brushed at least once each shift and fine sand and gravel are removed for burial or used as fill.

Decks and walks are hosed at least once each day. Where pressure is not available for hosing, secondary effluent may be used with a portable pump.

Grit removal. If grit appears in channels or hoppers the grit chamber operation should be checked. If the unit does not have a grit chamber, one should be installed. However, since grit is a sign of breaks in the sewer system or storm water connections the system should be checked before a grit chamber is built.

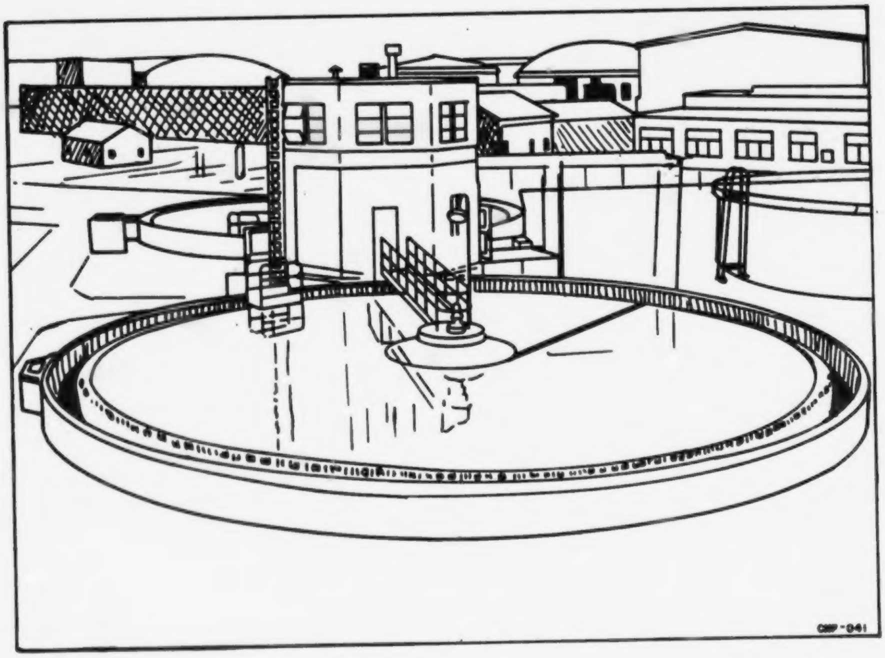


Figure 7-3. Circular Primary Settling Tank

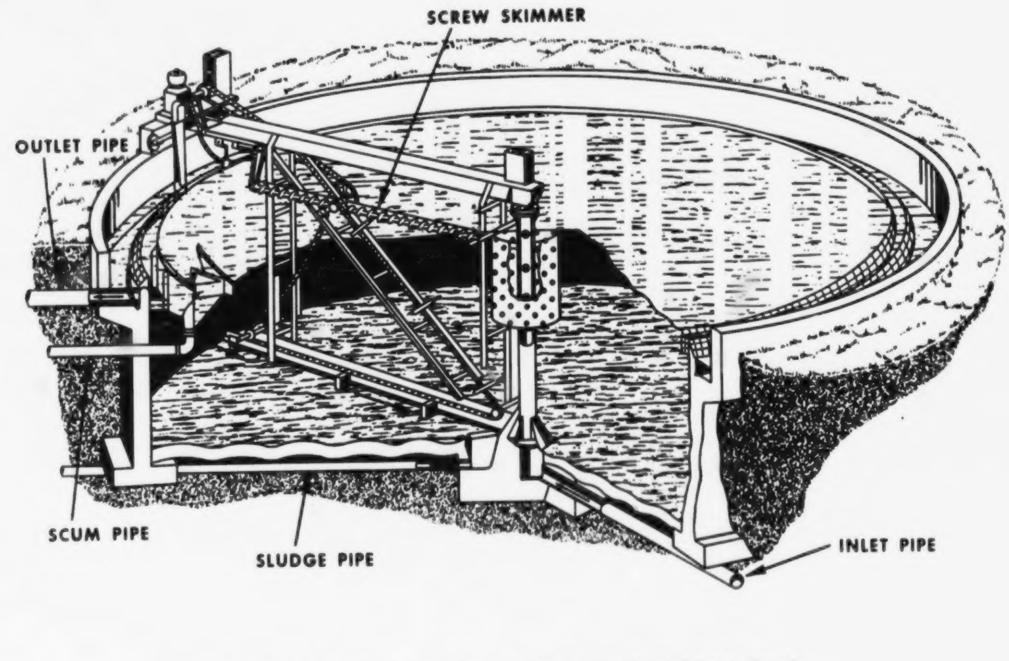

SCREW SKIMMER
OUTLET PIPE
SCUM PIPE
SLUDGE PIPE
INLET PIPE

Figure 7-4. Circular Primary Settling Tank

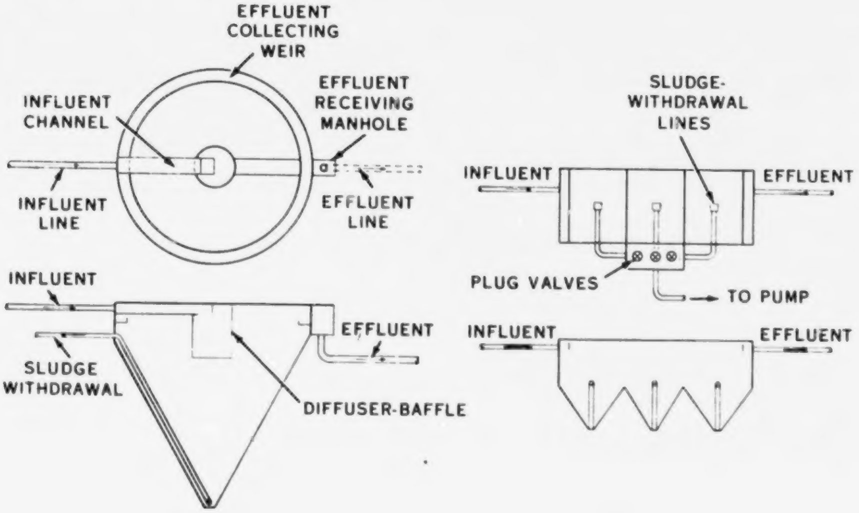


Figure 7-5. Multiple-Hopper Settling Tank

Sludge Withdrawal. Proper sludge withdrawal is important to settling efficiency. A flexible schedule of withdrawing concentrated sludge must be established with the following factors considered.

The sludge solids content should be as high as possible. This means a slow rate of withdrawal and stopping withdrawal when sludge becomes thin.

The amount of water in the digester must be reduced wherever possible because it affects digester operation. A decrease in the solids content causes a larger volume of sludge to be heated, a greater volume of digester supernatant to be returned, and a reduction of effective capacity. Example: 3 pounds of dry solids pumped as a 3-percent sludge puts into the digester 97 pounds, or about 11.7 gallons of water; the same dry solids pumped in as a 6 percent sludge add 47 pounds or 5.65 gallons of water, about half as much. Sludge must be drawn slowly (50 to 60 g.p.m. or less) to avoid pulling light sludge and wastewater to the intake; it is sampled during the drawing to note the consistency and obtain the composite sample. A quick-opening 2-inch valve must be provided for sampling if other means are not available. Sludge of thin consistency can be recognized from experience by correlating its appearance with sludge solids test results.

Hopper bottom tanks used as separate settling tanks require more care in drawing sludge because of the larger number of hoppers. Sludge from the hoppers at the effluent end normally has a low solid content, but must be removed to prevent carrying over with the effluent. Hoppers are squeegeed several times each week to remove adhering solids.

The interval between removals is regulated by wastewater load and weather conditions. Shorter intervals are required during high flows of strong wastewater and during warm weather. If sludge rises from the hoppers removal is incomplete or too infrequent.

Sludge should normally be removed from primary settling tanks three to four times each 24 hours. Sludge collected in settling tanks following standard trickling filters is drawn at least once each day except during filter sloughing when more frequent withdrawal is advisable.

Good judgment is necessary to find a balance between high solids concentration and a clean tank bottom, especially where light sludge from secondary treatment processes is returned to the primary tank for resettling.

Mechanical sludge collectors in circular tanks and all settling tanks for activated sludge must be operated continuously. Intermittent operation of circular tank mechanisms cause solids to accumulate on the tank floor placing a large starting load on the mechanism. Continuous operation provides greater sludge compaction. Sludge collectors in rectangular tanks are not usually operated continuously although it may be done, especially when the wastewater is strong and the rate of flow high. The mechanism should normally be started from 1 to 2 hours before pumping. The tank length governs the length of this period somewhat. At least two complete runs for the length of the tank is desirable. The tank bottom must be well cleaned and old sludge removed to the hoppers. Rising gas bubbles and sludge along the tank indicate incomplete cleaning or too long a period between operation. Hoppers in rectangular tanks should not be filled to more than 6 inches from the top. In withdrawing sludge, 2 feet of sludge blanket may be left in the hopper. Where there are two or more hoppers, only one should be drawn at a time.

The daily volume of sludge removed is measured by the following methods:

- When sludge is drawn to an open sump before pumping to the digester, calculate volume of the sump per foot depth. Measure depth of sludge in the sump by calibrating a rod in reverse so that the measurement may be made from the top of the sump to the surface of the sludge.

- When sludge is pumped directly from the clarifier, estimate volume by minutes of pump operation multiplied by actual gallons per minute output. This requires calibration of the pumps. If reciprocating valves clog, that time is not included.

- Where floating covers are installed in digesters, check volume of sludge pumped in several days against the above calculation by the rise of the cover. This procedure is one way to calibrate the sludge pump.

Methods of Control. Suspended solids and settleable solids tests are the primary measures of efficiency since solids removal is a primary function. Proper operation should remove 90 percent of settleable solids and 45 to 60 percent of suspended solids. Low solids removal may be caused by short circuits in the tank, incomplete removal of sludge, incomplete collection of sludge from tank floor, short detention period causing high velocities, or long detention periods following gas formation in tank.

BOD reduction is a secondary way to find tank efficiency. Low BOD reduction with normal suspended solids removal usually indicates septic action caused by a long detention time or incomplete sludge removal. A pH value of the tank effluent lower than that of the influent also shows detention time to be too long.

Analysis of sludge samples for solids content. Sampling the tank bottom for presence of solids and the appearance of rising gas or sludge shows whether or not the methods of removal are effective.

Causes of low efficiencies must be found and corrected; continued difficulty is reported to higher authority for advice and correction.

Records and Reports. The following data is reported monthly:

- For influent and effluent of tank; settleable solids, pH, suspended solids, and BOD.

- For primary tank sludge; volume removed, pH, percent solids, percent volatile matter.

- Changes in the number of tanks in operation.

In addition to the data required monthly, the following daily records are kept:

- Volume of sludge returned or recirculated to raw wastewater or other plant units (refers generally to secondary sludge).
- Volume and disposition of skimmings.
- Remarks on operating difficulties.

Imhoff Tanks

The main parts of an Imhoff tank are shown in Figure 7-6. Wastewater flows slowly through the top (sedimentation) chambers. As the solids settle they pass through a slot in the hopper bottom to the sludge digestion chamber. The slot is built so that gas produced in the sludge digestion chamber will not go back through the slot. The gas is diverted to a gas vent where it may be collected as fuel or released to the air. Solid particles which rise with the gas are also held in the sludge digestion chamber. The settling and sludge digesting compartments are separate so that the gas which is produced in the digesting process will not keep the solids from settling.

The digested sludge may be pumped out, or it may be removed by gravity flow. The speed of sludge digestion depends on temperature so the size of the sludge digestion compartment depends on temperature as well. A sludge capacity of three to four and one-half cubic feet per person is average.

OPERATION AND CARE OF SETTLING COMPARTMENT. Imhoff tanks require regular and frequent attention to maintain its efficiency and to minimize odor and sight nuisances.

Regulation and Reversal of Flow. Proper distribution of the influent to the settling compartment is essential to efficient settling. Where two or more units are installed, flow is distribution between units by adjusting the influent gates. Properly placed dividing lines of bricks or triangular blocks of concrete may sometimes be used in the influent channel to divide the flow. Leveling of outlet weirs is necessary to equalize distribution between units. With long tanks, most of the solids may tend to settle at the influent end. Separate channels are used to reverse the flow, using the entire digestion space to full capacity. If uneven sludge distribution occurs, flow must be reversed each month. Settling compartments have influent and effluent baffles which should not extend more than 18 inches below the wastewater surface. The influent baffle distributes incoming flow more equally across the entire compartment.

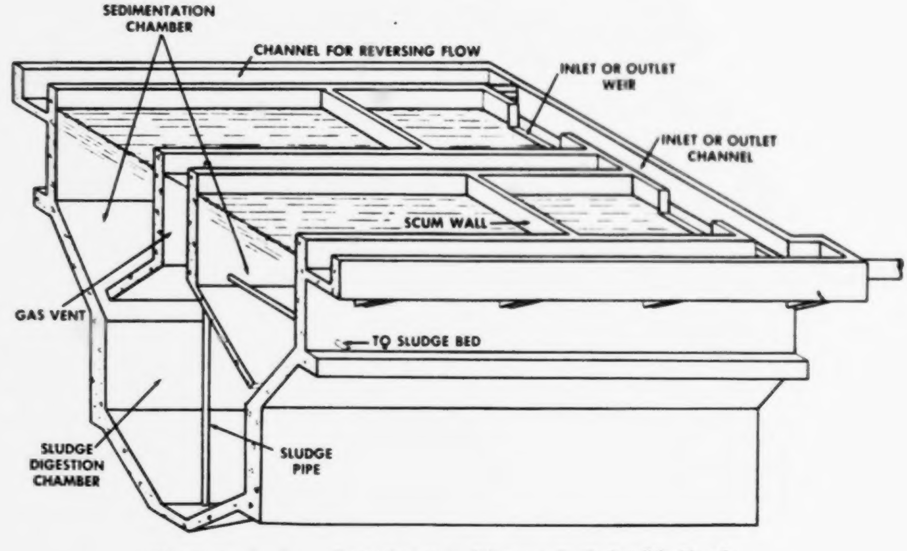


Figure 7-6. Sectional View of Imhoff Tank

Cleaning and Scum Removal. Care must be taken in all tank cleaning operations to avoid excessive stirring of the wastewater. This interferes with the natural settling of the solids and may cause skimmings to pass under the baffles. All walks, tops of walls, and exposed interior walls should be cleaned by hosing and scraping once a day. The channels and tank walls of the settling compartments must be kept clean and free from grease, scum and gritty deposits. Scum on the surface of the flow compartments must be skimmed off. Scum is the floating matter such as grease, oil and froth (suds). Skimmings should not be placed in gas vents because excessive amounts cause odor nuisance. Skimmings should be transported daily in covered containers to an incinerator or sanitary landfill and buried promptly with a thin cover of earth. Recover with an additional 6 inches of earth after 24 hours. A spray of water (final effluent may be used) helps to settle floating solids in the settling compartment (see Figure 7-7). Solids sticking to the upper sides of the hopper bottom of the settling compartment must be pushed through the slots weekly or more often if necessary. A longhandled squeegee is a suitable tool for this purpose. A heavy chain attached to a long handle pole is used to clean the slot along the settling compartment (see Figure 7-8).

OPERATION OF DIGESTION COMPARTMENT. The sludge digestion compartment in an Imhoff tank and in separate sludge digesters operates in a similar manner.

Control of Sludge Level. Sludge must not be allowed to accumulate above a level of 2 feet below the slot in the settling compartment. If the slot is not adequately trapped, it is necessary to keep the sludge level much lower to prevent the sludge solids from passing up through it. Sludge must be withdrawn frequently enough to maintain the proper level.

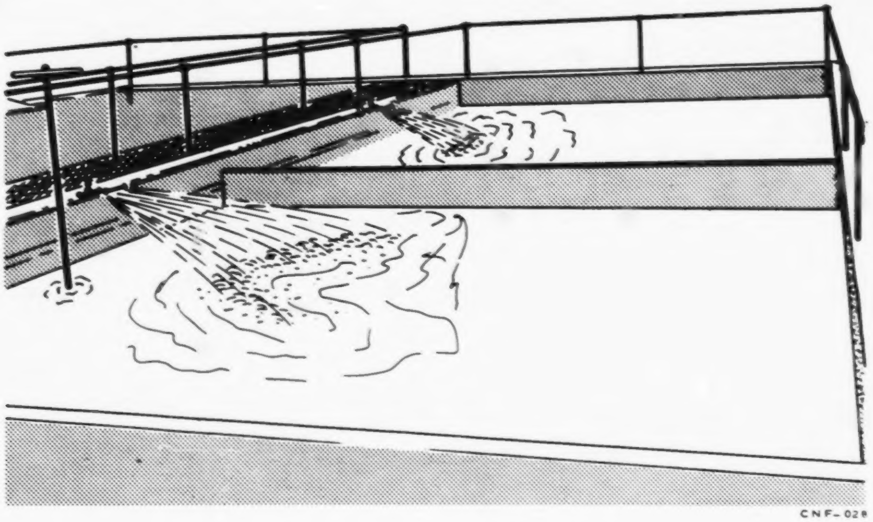


Figure 7-7. Water Spray Used to Settle Floating Solids

Small draw-offs monthly or more often, should be made, rather than large draw-offs at longer intervals. Only well-digested sludge should be withdrawn leaving enough in the compartment to prevent acid digestion and foaming. The collection of solids in the tank before any treatment has been given is called raw sludge. Usually not more than half the depth of sludge should be removed at one time. In northern climates however, sludge must be drawn down far enough during summer and autumn to allow ample room for winter accumulations when sludge digestion proceeds more slowly. The availability of sludge drying beds regulates withdrawal at some plants. Sludge must be drawn down during dry seasons to allow sufficient capacity in the sludge compartment for long, rainy seasons when sludge drying may not be possible.

Measurement of Sludge Depth. When the tank is operating at near capacity or when there is a possibility of overloading, the depth of sludge in the digestion compartment should be measured weekly at both inlet and outlet ends of the tank. Monthly measurements are sufficient if the wastewater load is less than 75 percent of rated tank capacity. The two methods of measuring sludge depth are the use of a pitcher pump with a rubber suction hose and an iron plate or weighted wood block.

A hand pump of the pitcher type is equipped with a rubber suction hose which is marked for length at 2-foot intervals and weighted at the end. With the pump in operation the hose is lowered through the slot in the settling compartment. The length of hose submerged when sludge first appears equals the sludge depth. A variation of this pitcher pump method involves the use of a graduated rubber suction tube weighted by a 4-foot steel pipe that forms part of the suction line. The tube is lowered through the gas vent instead of the slot; otherwise, the measuring procedure is the same.

An iron plate or a weighted wood block, 12 to 18 inches square, can be attached to a graduated wire or chain and lowered through the gas vent. The plate stops when the sludge level is reached. The distance from the surface to the sludge level may then be measured to determine the sludge depth.

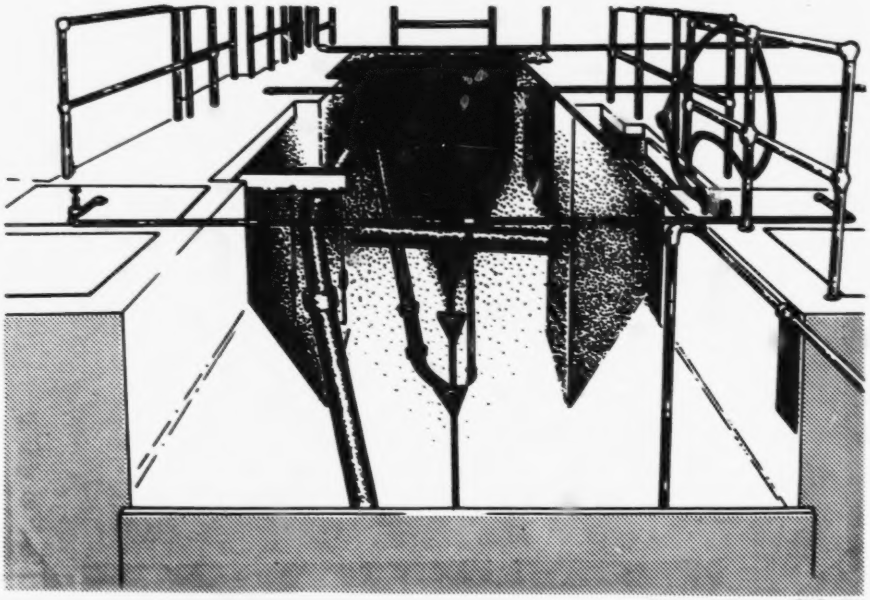


Figure 7-8. Empty Settling Compartment Showing Hopper and Slot

Sludge Removal. Well-digested sludge is black and granular with a tarry odor. It has a pH above 7.0 and a volatile solids content of about 50 percent. It drains and dries readily on sand beds and does not breed flies on beds during drying periods. The digested sludge must be drawn off slowly to allow the mass to settle evenly. Otherwise, a cone will form above the sludge outlet which may let partially digested sludge and raw wastewater out with the digested sludge.

If the outlet pipe clogs, flow may be started by applying recirculated effluent or water under pressure (not connected to the potable water system) through a hose in the sludge riser pipe. Opening and closing the sludge valve may also relieve clogging. Sludge may also be agitated or stirred with long rods inserted through slots, gas vents, or riser pipe. After sludge is withdrawn the sludge lines must be flushed out or filled with water (unless there is danger of freezing) to prevent drying and hardening of solids in the pipes.

Gas Vents or Scum Compartment. Solids rising with digestion gases accumulate and form scum in gas vents. This scum must be broken up as frequently as necessary to allow the entrapped gases to escape and floating matter to drop back into the digestion compartment. One or more of the following methods may be used: breaking up the scum with a rake or hoe; hosing scum with water under pressure using a fine spray; keeping the scum wetted down with water, or by transferring warm liquor from the digestion compartment by means of a portable pump. The use of large quantities of water should be avoided because it creates subcurrents. Heavy or dry scum should be shoveled off before scum reaches one foot in depth and placed on drying beds. In cold weather frozen scum must be removed frequently to let gas escape.

Foaming. Foaming is indicated by the rise of large amounts of black, sudsy, offensive scum in the upper part of the digestion compartment, in the gas vents, and in some cases, through the slots. Acid digestion lowering of pH and the formating of gas with high carbon dioxide content follows this condition. If it is not checked the foam may overflow into the settling compartments and carry with it suspended soilds from the digestion chamber.

Causes. Foaming occurs when raw solids accumulate faster than they can be digested and is usually brought about by the following:

1. Starting the tank without first seeding the sludge with well-digested matter; this is especially applicable when new tanks are placed in service.

2. The change to warmer weather from low winter temperatures when there has been a lack of digestion.

3. Excessive withdrawal of digested sludge.

4. High grease content of wastewater solids.

5. Insufficient digestion capacity.

Controls. Careful operation will prevent foaming. If it occurs, the following methods will control or minimize it:

1. Mixing digested sludge with raw sludge before starting the tank.

2. Periodic heavy hosing or use of a continuous water spray to break up the foam.

3. Application of sludge or sludge liquor from the hopper bottoms to the gas vents by means of an air lift or portable pump, thus mixing the foam with digested sludge.

4. Addition of hydrate lime slurry if sludge pH is below 6.5. Add sufficient lime in this suspension direct to the sludge compartment by means of a pipe inserted into the gas vents at different points. Add sufficient lime to adjust the pH to 7.0.

5. Putting the tank out of service until the foaming subsides is the most effective method when at least one other tank is available. Reducing the flow to the foaming Imhoff tank and avoiding a detention of more than 6 hours will help prevent septic conditions.

6. Drawing off incomplete digested sludge if the compartments are heavily loaded; an application of hydrated lime to the sludge during withdrawal helps to reduce odors and fly breeding on the drying beds.

7. Where digester capacity is inadequate and additional construction is delayed, building deep temporary lagoons that will provide additional digester capacity and are equipped for sludge removal to drying beds.

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CONTROL METHODS FOR IMHOFF TANKS. The settling compartment is controlled in smaller plants by settleable solids tests and pH determinations. Tests for suspended solids and BOD are added for larger plants. Normal operation should result in a settleable solids reduction of 90 percent or more, a suspended solids reduction of 50 to 70 percent, and a BOD reduction of 30 to 40 percent. Causes for lower efficiencies should be determined and corrected.

Digestion Compartment. Digestion compartment control is guided by weekly or monthly sampling of sludge depth and sampling of digested sludge at the bottom of the compartment before sludge is drawn to the drying beds. Tests for sludge pH are made at all plants, and tests for solids and volatile solids at larger plants when directed. Experienced operators can tell when sludge is well digested by its granular appearance and tarry odor.

Oil and Grease in Sewage Flow. Oil and grease in raw wastewater entering an Imhoff tank or other treatment unit cause difficulties such as interference with digestion, floating of solids, and increase of BOD. Such wastes should be intercepted before entering the sanitary sewer system.

Separate Digesters and Components

Organic matter in sludge furnishes food for bacteria and other microorganisms. While passing through them it breaks down into simpler and more stable substances. This is the basis of the sludge digestion process, which produces three final products: digested sludge, supernatant liquor, and gas. Digestion reduces the volume of sludge to be handled, simplifies disposal, and provides a more stable and inoffensive product that under certain conditions may be used as a soil conditioner. The organic matter in sludge is reduced to simpler and more stable forms and a considerable part of the solids is changed to liquids and gases. Digested sludge is dried on drying beds; supernatant liquor is returned to the raw wastewater entering the plant; gases are burned or used to provide heat or power for the digester or treatment plant. The gas may also be used to operate gas engines for pumping or other plant purposes.

There are three types of digestion tanks. They will be covered in the following paragraphs.

UNCOVERED TANKS. Uncovered tanks are ususally hopper-bottom tanks without gas collection or heating equipment. They are used on small units or for storing partly or fully digested sludge from other digesters.

FIXED COVER TANKS. Fixed-cover tanks may be used for economy on single, two-stage, or two-story digestion tanks. It is also necessary that they be used under conditions where snow and ice would interfere with the movement of floating covers. Because the fixed-cover digester must be kept full to keep out air, withdrawal of supernatant liquor must be done at the same time and in the same amount as the addition of fresh sludge.

Digesters of this type are usually concrete structures with sloping bottoms; they may or may not be equipped for heating and mixing sludge and for scum-breaking. The cover may be a flat or domed concrete slab with or without space for gas between it and the liquid level in the tank. More commonly, gas space is provided by a small dome of concrete usually located in the center of the cover (see Figure 7-9). The gas dome and seal are usually connected to a boiler or waste burner and must always be provided with a flame arrester. The sludge is heated by external means or by hot water passed through pipes arranged in coils near the inside walls or hung from the roof of the tank. External sludge heating is a more recently developed method of maintaining proper sludge temperatures.

FLOATING COVER TANKS. Floating cover tanks are of two kinds: one is equipped with a cover that "floats" on or moves up and down with the liquid level in the tank; the other has a gas-holder cover that is supported by the gas pressure in the tank. (See Figure 7-10.)

CAUTION: Sludge must not be withdrawn from a floating cover tank when the cover is at its lowest position and resting on its support brackets.

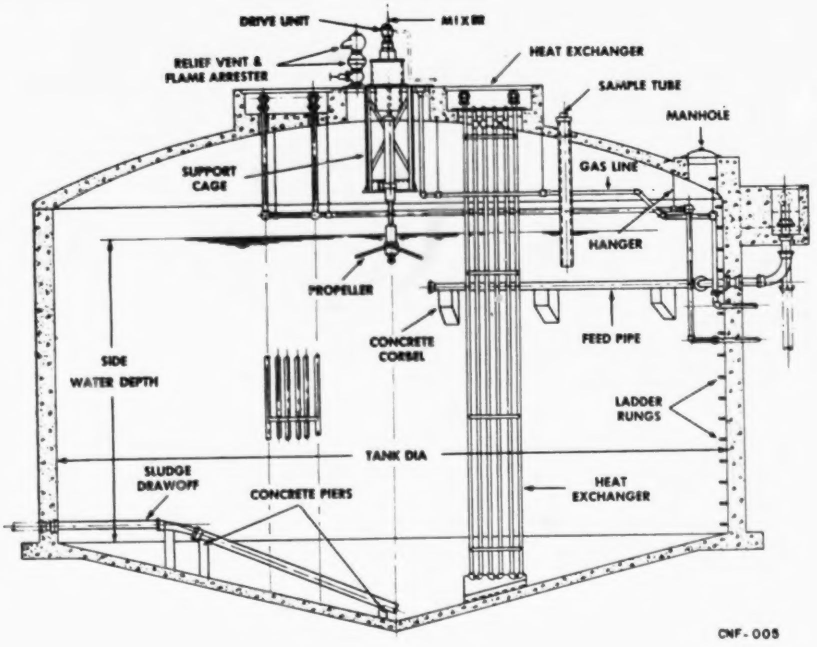
DRIVE UNIT
MIXER
RELIEF VENT & FLAME ARRESTER
HEAT EXCHANGER
SAMPLE TUBE
MANHOLE
SUPPORT CAGE
GAS LINE
HANGER
PROPELLER
CONCRETE CORBEL
FEED PIPE
SIDE WATER DEPTH
LADDER RUNGS
TANK DIA
SLUDGE DRAWOFF
CONCRETE PIERS
HEAT EXCHANGER
CNF-005

Figure 7-9. Digester with Fixed Cover

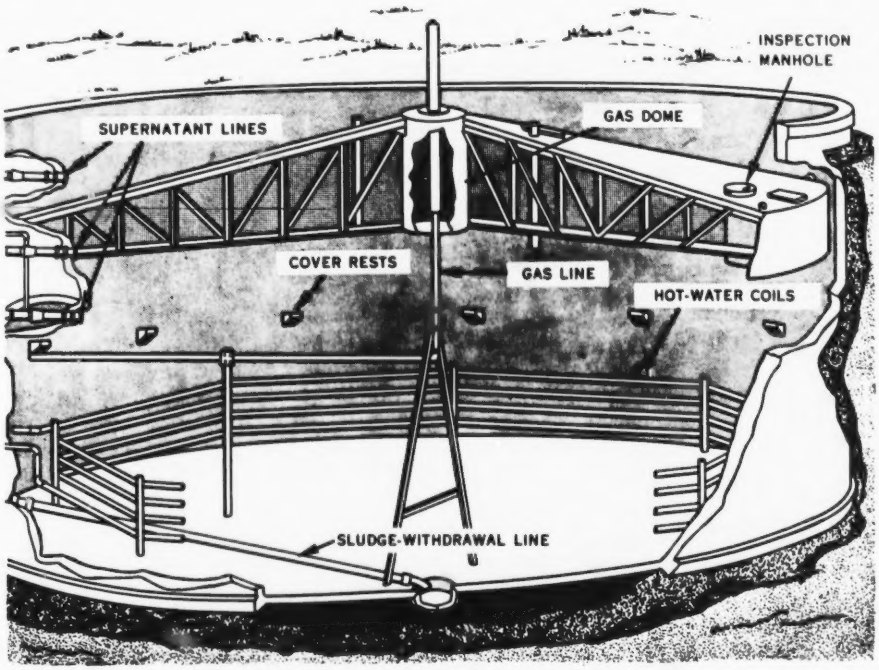
INSPECTION MANHOLE
SUPERNATANT LINES
GAS DOME
COVER RESTS
GAS LINE
HOT-WATER COILS
SLUDGE-WITHDRAWAL LINE

Figure 7-10. Floating Cover Digester

STAGES. There are three stages in the digestion of fresh sludge due to the fact that various compounds in wastewater break down at different rates. A high acid stage is marked by a low pH and gas production of a high carbon dioxide content. This is soon followed by a less acid stage and finally by a fermentation stage in which the pH rises toward the alkaline side of the pH scale. After the third stage is reached, BOD decreases sharply. Most of the floating solids settle, and the methane gas is produced in volume. In a properly operated digester the three stages proceed simultaneously on the solids in the order of their age in the digester. When a digester is placed into service the first two stages prevail for some time with the third stage starting later. After the third stage is established, fresh sludge may be added without appreciably affecting the characteristics of the tank contents. The three stages gradually merge until little evidence of the acid stages remains. Rapid digestion follows with heavy evolution of gas with high methane content. The resulting sludge is relatively stable and can be handled without any considerable odor nuisance.

TEMPERATURE. Temperature determines the rate of digestion. Mesophilic digestion, which progresses best between 40° and 105°F, is generally used. Above 105°F the organisms of mesophilic digestion become inactive and thermophilic digestion occurs. The latter range is not presently used because of the odors and operating difficulties. Approximate time of digestion at different temperatures can be determined from Figure 7-11. Between 90° and 100°F well-digested sludge is produced in about 24 days. At 85°F, 90 percent of digestion is completed in 26 days; at 75°F, 35 days; and at 55°F, 65 days. High temperatures are more difficult to maintain and require considerable heat transfer, especially in the cold climates. The practical operation range is between 85° and 95°F.

VOLATILE ACIDS. Volatile acids are organic acids which are formed in the sludge in a digester by anaerobic bacteria in the stabilization of organic matter. The test for volatile acids is performed on a sludge sample, taken from the digester. The volatile acids test will help the operator determine the overall health of the digester, and may be used as a "control test" for anaerobic digestion.

In addition to sludge, the digester contains a watery liquid called "supernatant liquor" which contains alkalinity. The ratio of volatile acids to alkalinity should be maintained between .1/1.0 and .3/1.0 for anaerobic digestion to progress satisfactorily. A ratio of .5/1.0 indicates trouble, foaming may occur and the bacteria may be killed. A high or increasing acid content indicates fermentation is occurring in the digester. This is a serious malfunction, but it may be corrected by adding chemicals to increase alkalinity.

Two causes for formation of an excessive VA concentration are:

1. Improper mixing of raw sludge with the contents of the digester.

2. Excessive quantity of raw sludge being pumped into the digester at one time.

Example of volatile acids:

vinegar-acetic acid-CH_3COOH
formic acid-ant-venom-$HCOOH$
citric acid-$C_6H_8O_7 \cdot H_2O$

The volatile acids test can be used as a control test for anaerobic digestion. The VA test measures the fatty acids that are present. This information is valuable to maintain digester control. If the acid content of a digester increases and continues to build up, the test will detect a condition of acid fermentation quickly. This is very undesirable. An excessive amount of volatile acid causes an ancid environment unsuitable for some of the bacteria in the digester and the digester may cease to function properly--unless alkalinity is added.

GREASE. Domestic wastewater contains a considerable amount of oils, fats, waxes and soap which are collectively called grease.

Objections to grease:

1. Interferes with the settling rate of solids, causing excessive scum accumulation.

2. Clogs pipes and trickling filters.

3. Deters the use of dried sludge as fertilizer.

Reasons for performing a test to determine amount of grease entering the wastewater treatment plant:

1. This information may be helpful in overcoming difficulties in plant operation.

2. Could show need for alternative method of disposal of plant effluent (might cause a surface film on receiving stream and/or shoreline deposits).

3. Could indicate nonsuitability of a particular batch of dried sludge for use as a fertilizer.

The grease concentration is determined by gravimetric test.

Grease and oils are resistant to anaerobic digestion. When present in sludge they cause excessive scum accumulation in the digester, clog the pores of filters, and deter the use of sludge as fertilizer.

A knowledge of the quantity of grease and oil is helpful in overcoming difficulties in plant operation, in determining plant efficiency in controlling the discharge of these materials in receiving stream. A knowledge of the amount of grease present in sludge can aid in diagnosis of digestion and dewatering problems, also to indicate suitability of a particular sludge for use as a fertilizer.

Procedures

1. Collect a 1 liter sample of raw wastewater.

2. Add 5 ml HCl (lowers pH to 2).

3. Transfer sample to separatory funnel.

4. Add 30 mL freon (this extracts grease and separates contents into two layers, freon at the bottom.

5. Drain freon.

6. Place freon in weighed distilling flask, place flask over steam bath, drive off freon.

7. Weigh flask plus grease.

8. Calculate mg/L grease.

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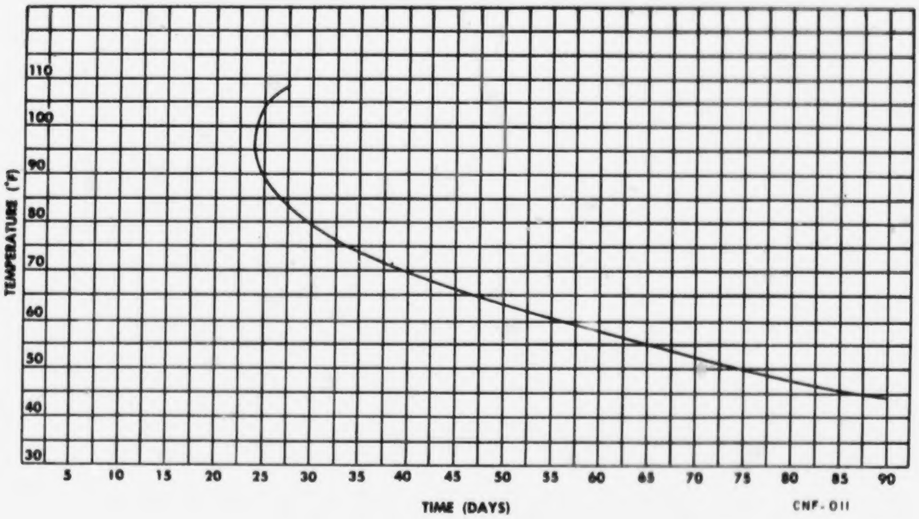


Figure 7-11. Time Required for Digestion of Wastewater Solids at Different Temperatures

NOTE: Detailed information and materials covered to this point in the study guide may be found in AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems, Part D, Sections 2 thru 8, pages 41 thru 100.

Sludge Drying

Sludge is removed from digesters, or from Imhoff tanks to drying beds. Mechanical filter also remove digested sludge to be dewatered and dried. This process may be accomplished through the use of drying beds or mechanical filtration. The dried sludge may then be disposed of in several different ways. It will be necessary to keep accurate records of the operation on a monthly operating log.

Well-digested sludge from the separate sludge digester or Imhoff tank has a water content of 90 to 96%. Digested sludge is generally dewatered at the treatment plant by underdrained sand and gravel beds, although natural sand areas are sometimes used. The sludge drying takes place both by evaporating from the surface and by draining through the sand and gravel. Water drainage through the bed is returned to the raw wastewater flow wherever possible. When plant elevation makes this impracticable, it is discharged to other points in the plant or to the receiving stream. In most cases it goes directly to the stream.

CONSTRUCTION FEATURES OF SLUDGE DRYING BEDS. In the construction of an underdrained sludge bed, the ground is dug to the desired depth and graded to form furrows. In these furrows open tile drains are laid in surrounding beds of gravel 6 to 12 inches deep. From 6 to 12 inches of sand is placed on top of the gravel and leveled. Outside walls and partitions between adjacent beds may be constructed of concrete, wood, or earth. The number and size of beds required depends on plant size and average drying time. Figure 7-12 shows a typical sludge bed. Glass covers, such as those used for greenhouses, may be installed over beds to increase drying efficiency to provide all-weather drying and to eliminate odor nuisance.

DRYING BED OPERATION. Effective sludge drying depends primarily on the condition of the sludge from the digester. Poorly digested sludge forms a heavy mat over the sand and sludge surface which slows drying. Sludge withdrawals from digesters and Imhoff tanks should be scheduled according to weather and seasons to make the best use of sludge bed capacity. Both digestion and drying are quickened in warm or dry weather permitting sludge beds to be cleaned and recharged. During cold weather sludge must be held in digesters or Imhoff tanks until good sludge-drying weather, unless glass-covered beds are available. Storing digested sludge in open tanks or lagoons may be necessary during cold or wet weather when drying is retarded. Normally, sludge lagooning should not be resorted to unless digester facilities are inadequate to store the sludge produced.

SLUDGE BED PREPARATION. Before sludge is applied to the bed the sand or other filtering medium must be clean, smooth, and graded slightly away from the point of sludge application to assure uniform depth and free passage of water. Sludge chunks, weeds, and other debris must be removed. A thickness of not less than 4" should always be maintained to assure a clean effluent and to keep solids from entering and settling in the underdrains. Clogged sand surfaces may be remedied by the removal of the top 1/4 to 1" of sand. Splash plates should be provided to prevent incoming sludge from falling directly on the sand surface and disturbing it.

SLUDGE APPLICATION. Excessive filling of sludge bed results in clogging, requiring a longer drying period in which moisture must be removed by evaporation alone. The best filling depth depends on the solid content of the sludge. A depth from 8 to 12 inches is generally recommended. If the bed area is ample, apply sludge and allow it to remain as long as possible to reduce the moisture content. The normally dried cake should be 3 to 4 inches thick with little sand and easy to handle. If the bed area is limited, sludge must be drawn more often and applied at minimum depths to promote quicker drying. Do not discharge wet sludge on dried or partially dried sludge. Drain sludge lines and flush with a small amount of water or supernatant after each use to prevent sludge from hardening in them. If it is necessary to draw partially digested sludge and fill sludge beds, hydrated lime suspension may be used to arrest decomposition. Add approximately 25 pounds of hydrated lime suspension to each 100 pounds of dry solids in the partially digested sludge. This sludge mixture will be difficult to remove and will dry slowly.

COAGULATION. The addition of floc-forming chemicals that cause sludge particles to adhere with the floc to form small masses of floc and sludge will allow more water to filter out and speed the drying process on sludge beds. This is not a normal procedure but may be used temporarily where it is necessary to speed bed drying to remove sludge from an overloaded digester. The most common coagulating agent is aluminum sulfate or filter alum. Alum in a water solution is mixed with the sludge by siphoning or injecting it into the sludge pipeline to the drying bed as near the digester as possible. As little alum as practicable should be used. One to two pounds per cubic yard (200 gallons) of sludge are usually required. The proper amount can be determined by mixing known quantities of sludge and alum and observing how the sludge flocculates and separates from the liquid.

REMOVING DRIED SLUDGE. Remove dried sludge when it can be picked up with a fork (not a shovel) without excessive sand sticking to the underside. Moisture content of this sludge usually ranges from 35 to 70%. Dried sludge may be moved rom the beds by wheelbarrow, truck, or tractor, but do not allow heavy equipment on the beds unless runways are provided to avoid crushing and clogging the underdrains. Long, covered beds are sometimes equipped with an overhead monorail for easy removal of sludge cakes.

MECHANICAL FILTRATION. Sludge may be preconditioned in preparation for mechanical filtration by washing or diluting the sludge in a tank with two or more volumes of water, mixing, allowing the sludge to settle, and then drawing off the supernatant liquid. This process, which is more effective with digested sludge than with raw sludge, is used to condition sludge for filtration or drying rather than as a separate drying operation. The supernatant is usually returned to the incoming raw wastewater.

Sludge must be chemically conditioned for filtration by mechanical filters. Of the numerous types of mechanical filters, the drum type and disk type are most widely used. Filter cloth is the usual filter-medium. It is stretched over copper mesh covering the exterior of a horizontal drum or the leaf of a disk-type filter. This drum revolves continuously and operates automatically through a filtering-drying-discharging cycle. Under the filter surface, a hollow inner shell forms a compartment sub-divided into sections. The inside of each section as it rotates is separately placed under either

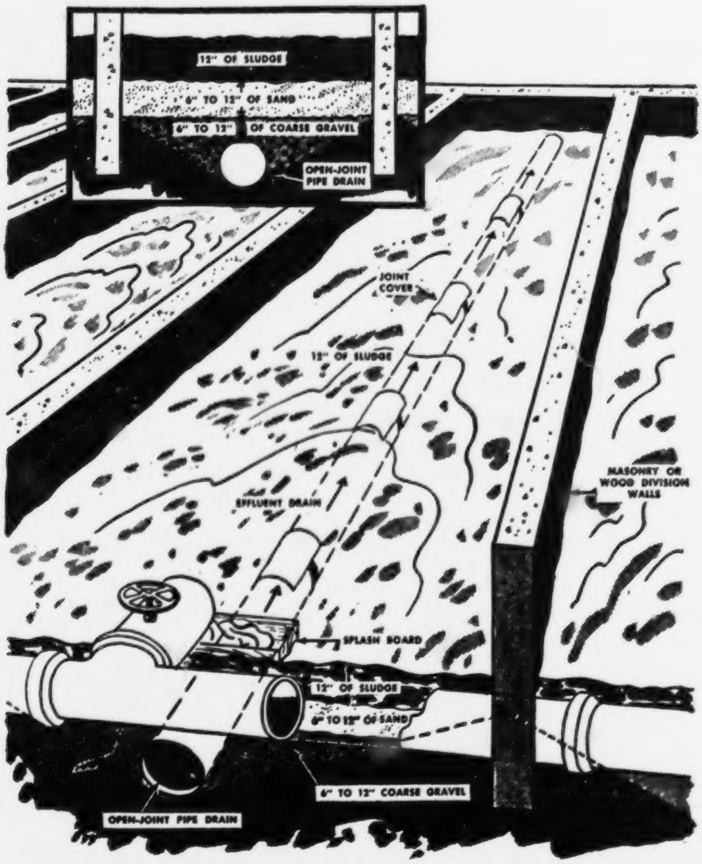


Figure 7-12. Sludge Drying Bed

vacuum or pressure. The filter revolves slowly, partly submerged in a sludge reservoir equipped with an agitator. As the drum passes through the sludge, a vacuum is applied to the inside of the submerged sections to pull a suitable thickness of sludge against the filter cloth. As the drum revolves from the sludge reservoir, the vacuum holds a layer of sludge to the drum and acts as a drying vacuum to draw the liquid into the sections returning the sludge solids in a cake on the filter surface. This filter cake, usually from 1/16 to 1/4", is automatically removed before the drum resubmerges. To help remove the cake from the drum, a slight air pressure is applied to the inside of the section as the cake reaches the removal point, causing it to be lifted or blown off the drum or disk. The broken cake falls into a receptacle or chute or onto a conveyor for transportation to a point for further drying or disposal. The sludge liquor removed is usually returned and mixed with the raw wastewater coming into the plant. Both vacuum-producing and air-compressing facilities are required for operating mechanical filters.

VACUUM FILTRATION. Vacuum filters are used for sludge dewatering at many large plants, or at smaller plants where there isn't enough land for sludge drying beds. Vacuum filters can also handle raw sludge. Figure 7-13 shows a vacuum filter. It consists of a large drum over which the filtering medium is placed. The filter medium can be a cloth of cotton, wool or synthetic fibers, a stainless steel mesh, or a double layer of stainless steel coil springs. The drum turns inside a tank with about one quarter of the filter surface submerged in sludge. Valves and piping are arranged so that a vacuum is applied to that part of the drum turning through the sludge. The vacuum is continued as the drum rotates out of the sludge and into the air. Toward the end of one turn, the vacuum is reduced and the sludge is scraped, blown or lifted away from the drum right before the drum enters the sludge tank again.

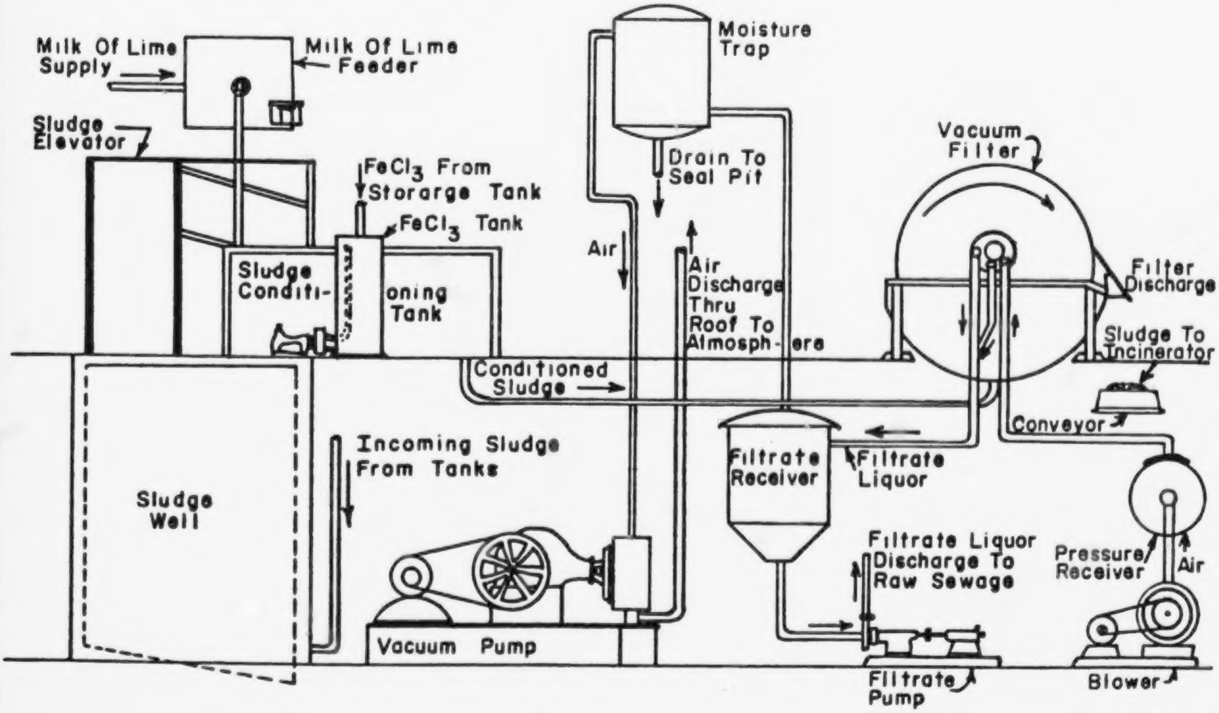

Milk Of Lime Supply
Milk Of Lime Feeder
Sludge Elevator
FeCl3 From Storarge Tank
FeCl3 Tank
Sludge Conditioning Tank
Moisture Trap
Drain To Seal Pit
Air
Air Discharge Thru Roof To Atmosphere
Vacuum Filter
Filter Discharge
Sludge To Incinerator
Conditioned Sludge
Conveyor
Incoming Sludge From Tanks
Sludge Well
Filtrate Receiver
Filtrate Liquor
Filtrate Liquor Discharge To Raw Sewage
Pressure Receiver
Air
Vacuum Pump
Filtrate Pump
Blower

Figure 7-13

Vacuum Filter System

Problems With Vacuum Filters. Sludge should be conditioned with chemicals and/or elutriated before it is vacuum filtered. This helps the water to drain more freely and results in a thicker, lighter and dryer cake and permits higher drum turning speeds. The rate of sludge yield from the filters is expressed in pounds of dry solids per square foot of filter surface per hour. This includes the weight of conditioning chemicals. The yield should be about 4 to 10 pounds per square foot (18 to 45 kg/m^2) per hour for primary and combined primary plus secondary sludge. Digested activated sludge filters poorly and may result in yields as low as 2.5 pounds per square foot (11 kg/m^2) per hour if it is not conditioned with chemicals. Moisture content of the sludge cake may vary from 65 to 80%, however, if sludge is to be heat dried or incinerated, the filter can reduce the moisture to 60%.

INCINERATION. Incineration is another method of drying and preparing sludges for disposal. Incineration will evaporate the excess moisture then destroy the pathogens and reduce the volume of sludge to an ash for safe disposal. Usually the disposal of sludges can be used as fertilizer or landfill. Incineration is very costly. This process is most helpful at plants in which there is no other way to get rid of the sludge. See figures 7-14a and b.

Sludge incineration involves several steps. First, the feed sludge temperature must be raised to 212° F (100° C). All water must evaporate from the sludge. The temperature of the dried sludge must be raised until the volatile solids ignite and burn. Most incinerators work in the range of 1600° to 2000° F (870° C and 1100° C). The most common types of incinerators are the multiple hearth and fluidized bed. Figures 7-14A and 7-14B show these. Incineration produces a residue or ash which can be disposed of without much trouble. However, it may also produce hazardous air pollution. To prevent air pollution, the incinerator must be working right and equipped with air pollution control units. The most common air pollution control units involve the use of "scrubbers" which spray water through the gas outlets. The water traps the pollution which is then drained to a chamber from which it must be disposed. National standards require a discharge for particulate emissions of not more than 300 mg/lb (0.65 g/kg) of dry sludge. Regulations may vary from state to state. Consult both local and state regulating agencies for applicable emission standards.

Sludge Disposal. Well-digested sludge contains about 4 to 10% total solids. The volatile solids content on a dry basis is below 55% and pH is over 7.0. Poorly digested sludge forms a heavy, sticky, clinging mat over the surface of both sludge and sand in drying beds and retards drying. Undecomposed grease in the sludge clogs the sand. Sludge must come well-digested from digesters and Imhoff tanks for it to dry quickly, completely, and without odors.

Sludge may be utilized for a useful purpose. Sludge drying is usually an additional expense, but it may be justified by local conditions.

DISPOSAL OF DRIED SLUDGE. Remove dried sludge from beds as soon as it can be handled and piled at an accessible place for grinding or hauling. It may be pulverized by a mechanical grinder for easier disposal and/or uniform spreading where it is used as a fertilizer.

Dried digested sludge may be used as a fertilizer. Wastewater sludge is not high in nitrogen, phosphates, or potash content; generally having 1.5 to 4.0% nitrogen, 1.5 to 2.5% phosphate, and usually no more than a trace of potash. The principal value of wastewater sludge is the humus content which averages from 25 to 35%.

Use of sludge for fertilizer is subject to restrictions. It should not be applied to crops which will be eaten raw. The frequent presence of hookworm eggs in sludge may cause infection where climate and soil favor continued hookworm activity. Digested sludge is particularly suitable for fertilizing vegetation cultivated for dust and errosion control, or for lawns, flower beds, and shrubbery. In many cases it is possible to sell excess dried sludge locally to nurseries or farmers.

Dry sludge may be used as fill in low areas not subject to heavy traffic. Care should be taken during disposal because the sludge will not support heavy equipment.

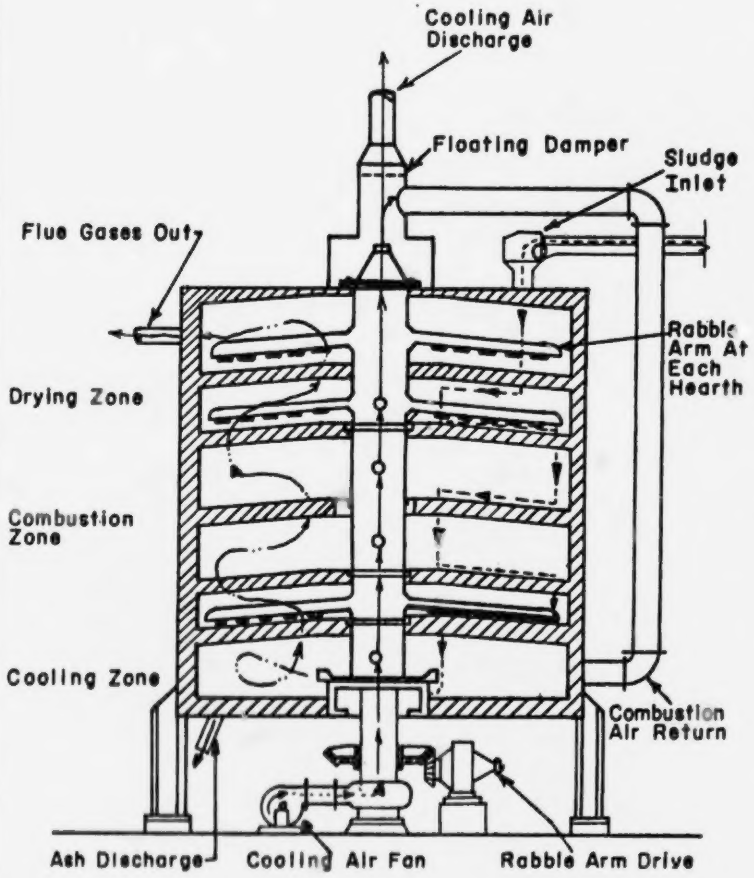

Cooling Air Discharge
Floating Damper
Sludge Inlet
Flue Gases Out
Rabble Arm At Each Hearth
Drying Zone
Combustion Zone
Cooling Zone
Combustion Air Return
Ash Discharge
Cooling Air Fan
Rabble Arm Drive

Figure 7-14a

Multiple Hearth Incinerator

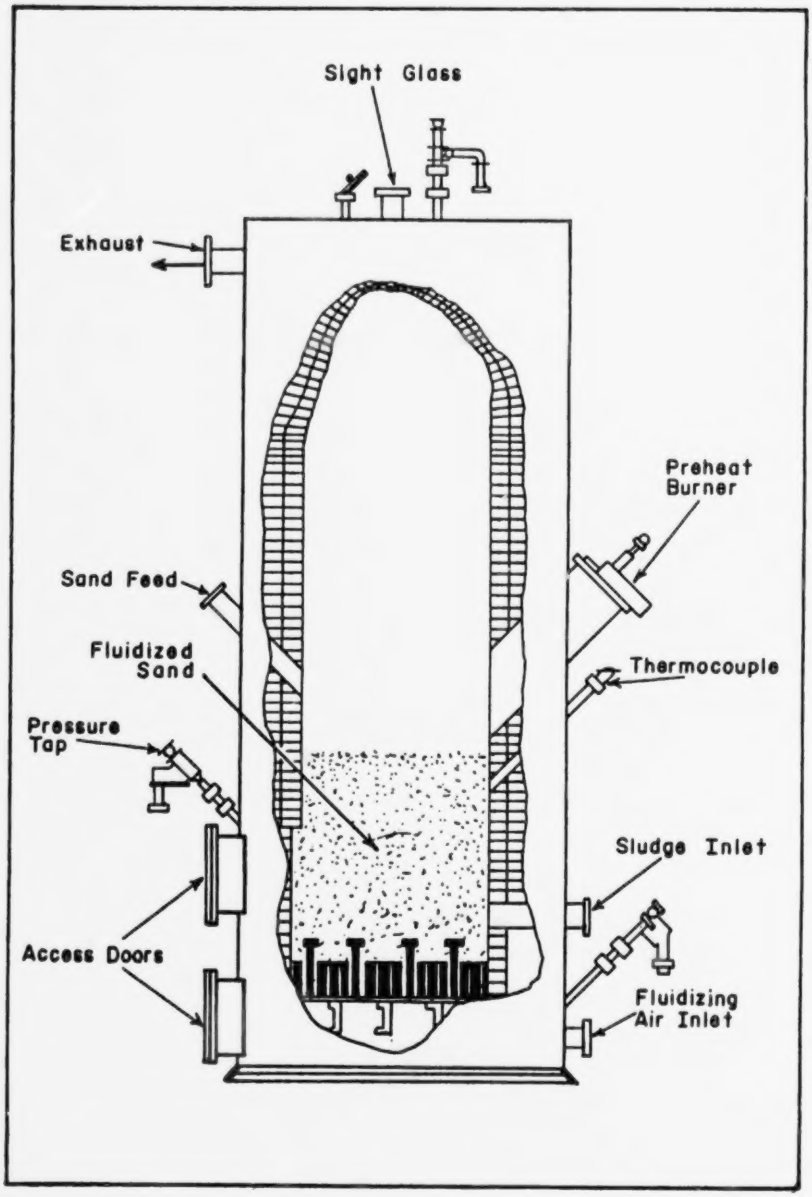

Sight Glass
Exhaust
Preheat Burner
Sand Feed
Fluidized Sand
Thermocouple
Pressure Tap
Sludge Inlet
Access Doors
Fluidizing Air Inlet

Figure 7-14b

Fluidized Bed Incinerator

DISPOSAL OF WET SLUDGE. In isolated areas wet sludge may be discharged directly from digesters to sludge lagoons instead of to drying beds. Lagoons can be constructed as simple earth-walled basins and underdrains may be provided when lagoons will be reused repeatedly. If only well-digested sludge is discharged into the lagoons they will be practically odor-free and the liquor from them will not be objectionable. In emergencies lagoons are sometimes used for digestion of raw or partially digested sludge in which case odor can be expected. Where large areas are available lagoons may be used until filled, then abandonded, and new lagoons constructed.

In some instances, particularly where drying bed faciliites are deficient, wet well digested sludge may be drawn into tank trucks and applied directly to areas being fertilized. Wet sludge is normally applied in quantities of 100 to 400 gallons per acre. Lawns may be sprinkled lightly immediately after application in order to wash the sludge into the roots of the vegetation.

Wet sludge may also be disposed of by transporting it in tank boats for dumping at sea.

RECORDS. Sludge drying will be reported on the monthly operating log to include the following:

Total gallons drawn to beds.

Average pH, percent solids, percent volatile solids.

Total cubic yards of dried sludge removed.

Average drying time in days.

Additional information required may be recorded in the remarks column or reverse side of the operating log. The information to be recorded is as follows:

Date, volume in gallons, and depths in inches of sludge applied to each bed by bed number.

Results of pH, percent solids, and percent volatile solids of each sludge withdrawal to each bed.

Date, volume in cubic yards, and disposition of sludge removed from each bed.

NOTE: Read the following chapters in AFM 91-32 for additional information: Chapter 13, Section 1, Pumping Sludge, para 13.1.1 to 13.1.7; Section 2, Anaerobic Digesters, para. 13.2.1 to 13.2.21.3; Section 4, Process Control, para. 13.4.1 to 13.4.14; Section 8, Sludge Tratment and Disposal, para. 13.8.1 to 13.8.15.

EXERCISE IV-7-7c

PART 1

INSTRUCTIONS

Using your SW J3ABR5631 000-IV-7, to complete the following statements.

1. What is the frequency of sludge removal from primary settling tanks?

2. What is the maximum depth to which hoppers in primary settling tanks may be filled?

3. Why is good housekeeping at the settling tank essential?

4. How often must floating material be removed from settling tanks?

5. Why must water volume in the digester be reduced whenever possible?

6. How do solids get from the settling compartment to the digestion compartment in the Imhoff tank?

7. What two methods may be used to remove digested sludge from the Imhoff tank?
   a.
   b.

8. What two methods may be used for disposing of skimmings from the Imhoff tank?

9. How often should sludge depth be measured in the Imhoff tank?

10. Oil and grease in the Imhoff tank cause what conditions?

11. What are the characteristics of well digested sludge?

12. What hazards are associated with digester gas?

13. What type of bacteria are in digesters?

14. What are the stages in the digestion of sludge?

15. What is the most satisfactory temperature operating range in digesters?

16. The purpose of a volatile acids test is to determine the ______________.

17. Why is it necessary to thoroughly mix fresh sludge with old sludge in digesters?

18. When grease and oil are present in an anaerobic digester they cause

19. Name three types of digester tanks.

    a.

    b.

    c.

20. Which type of gas is produced in the largest volume in digesters?

21. What records must be kept on digesters and gas equipment?

22. What is the water content of well-digested sludge?

23. What are the advantages of covering a sludge drying bed with glass?

24. What is the corrective action for a clogged sand surface in a drying bed?

25. What is the most common coagulating agent used in sewage?

26. How is dried sludge removed from the drying beds?

27. How is sludge conditioned for filtration? ______________________________

____

28. In the filtration process, what is used to pull the sludge against the filter cloth? ______________________________

29. Well-digested sludge contains what percent total solids? ______________

30. What is the depth of sludge in a drying bed? ____________________

31. What is the depth of gravel in a drying bed? ____________________

32. What is the depth of sand in a drying bed? ____________________

PART 2

INSTRUCTIONS

Using your SW J3ABR56631 000-IV-7, fill in the blanks.

1. Separate settling tanks or clarifiers are single purpose structures for removing ______________ ____________________.

2. Sludge hoppers are emptied by ______________ or by ____________________ while tank remains in operation.

3. The normal detention periods of primary and secondary settling tanks should be ____________________ for average daily flow.

4. Good housekeeping at the settling tank is essential to prevent ______________, ______________ and ______________ ____________________.

5. Floating material must be removed ______________ each shift or ______________ if present in large quantities.

6. A spray of water under pressure directed against floating material frequently ____________________ floating material.

7. Sludge should be removed from primary settling tanks ____________________ to ______________ times each 24 hours.

8. Sludge hoppers in rectangular tanks should not be filled more than ______________ ____________________ from the top.

9. The ____________________ distributes incoming flow more equally across the entire compartment.

10. Sludge must not be allowed to accumulate above a level of ____________________ ____________________ the slot in the settling compartment.

11. The settling compartment is controlled in smaller plants by ____________________ ____________________ tests and ____________________.

PART 3

INSTRUCTIONS

Using your SW J3ABR56631 000-IV-7, fill in the blanks.

1. The three types of digestion tanks are ____________________, ____________________ and ____________________.

2. When heating the sludge in a digester, you use ____________________ heating or ____________________ heating.

3. The three stages in the digestion of fresh sludge are ____________________, ____________________ and ____________________.

4. At 85°F, ____________________ percent of digestion is completed in 26 days.

5. Floating cover tanks are of two kinds, they are ____________________ and ____________________.

PART 4

INSTRUCTIONS

Place the appropriate number from the given list of components in the circles provided, using Figure 7-15.

a. Joint cover
b. Masonary or Wood Division Walls
c. Splash Board
d. 12" of sludge
e. 6" to 12" of sand
f. Effluent Drain
g. Open-joint pipe drain
h. 6" to 12" coarse gravel

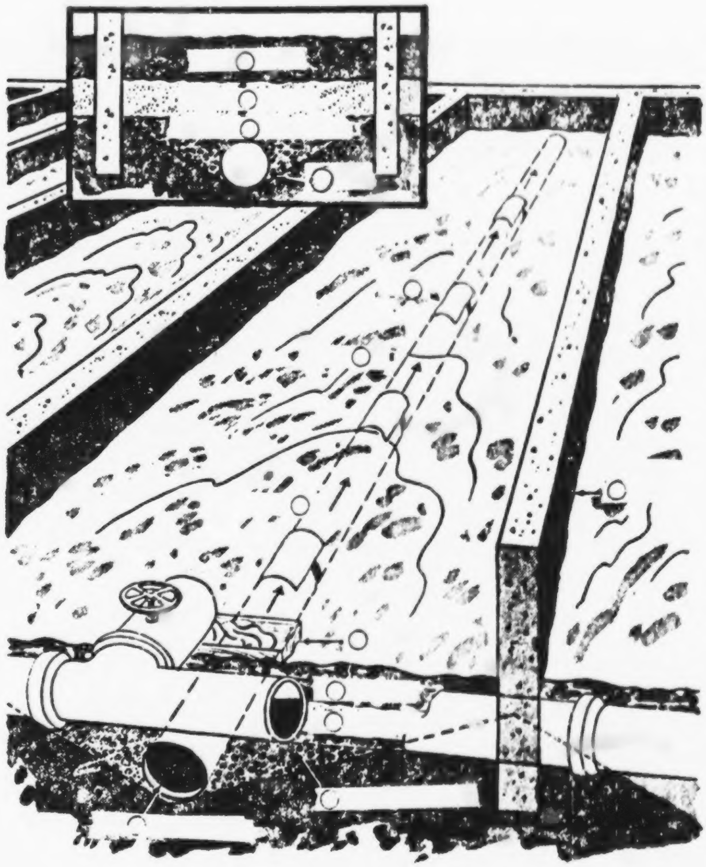


Figure 7-15. Sludge Drying Bed

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

EXERCISE IV-7-7d

INSTRUCTIONS

Using AFM 91-32, Chapter 4, 7, 13 and SW J3ABR56631 000-IV-7, complete the following statements.

1. How often must the tightness of the bolts be checked that hold the skimmer arm in place on the drive shaft of the circular clarifier? ____________________

2. List three causes for clogged sludge lines.
   a. ____________________
   b. ____________________
   c. ____________________

3. What would be the likely causes for irregular or jerking motion of skimmer and sludge collectors?
   a. ____________________
   b. ____________________
   c. ____________________
   d. ____________________
   e. ____________________

4. What is used to clean the upper sides of the hopper bottom of the settling tank of the Imhoff tank? ____________________

5. What is used to clean the slot along the settling compartment of the Imhoff tank?

   ____

6. What causes excessive foaming in the digester? ____________________

   ____

7. What causes the fluctuating temperature in a digester? ____________________

   ____

8. A decrease in gas production is likely caused by
   a. ____________________
   b. ____________________

9. Likely cause of decreased digester capacity. ____________________

   ____

10. How do you clean the sludge drying beds? ______________________________

____

11. Why do we need to replace the sand in a drying bed? ______________________

____

12. Vacuum filter media should be cleaned well after each run or ______________

to ______________ hours of operation.

13. The scraper or "doctor" blade should be carefully adjusted to keep it from tearing

the ____________ ____________, on the vacuum filter.

14. Raw, undigested sludge is unfit for land spreading because it often

contains many ________________________. Raw sludge must be plowed under

as soon as it is applied to avoid ______________ ________________.

________________ ________________ should only be used when other sludge

15. disposal facilities are not available.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

Primary settling tanks are used to remove settleable solids from the wastewater. Sludge deposited in the bottom of these is removed to a separate digestion tank. The settling of solids in primary settling tanks is generally not aided by chemicals or coagulants. These type tanks can be classified according to their methods of sludge collection. Primary settling tanks may be rectangular, circular or square.

The Imhoff tank is a two-compartment tank. As anaerobic decomposition takes place in the digestion compartment, the gases produced rise and may be collected for fuel or be allowed to escape to the atmosphere. The separation of the settling and digestion processes permits more efficient settling, keeps wastewater in upper compartment fresh, makes digestion more complete, and produces a better effluent.

The sludge collected in the primary settling tank is usually treated in a digester. The digester reduces the volume of the sludge and converts it to a more stable form. The organic matter in sludge is decomposed and stabilized by the action of anaerobic bacteria. (Anaerobic bacteria are able to live in absence of free oxygen.) The final products of digestion are digested sludge, sludge liquor, and gases. The digestion process has three stages: high acid, less acid, and fermentation.

REFERENCES

1. AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

2. AFM 88-11, Chapter 3, Sewage-Treatment Plants

3770th Technical Training Group
Sheppard Air Force Base, Texas

SW J3ABR56631 000-IV-8

OPERATION AND MAINTENANCE OF SECONDARY WASTEWATER TREATMENT UNITS

OBJECTIVES

Given a list of incomplete statements and a list of terms and phrases relative to the operation of trickling filters, complete the statements IAW to AFM 91-32. Eight of the twelve completed statements must be correct.

Given information and a troubleshooting guide, identify the maintenance requirements for trickling filters by following a troubleshooting guide with a maximum of one instructor assist.

Given information and incomplete statements related to wastewater lagoons, write the correct term or phrase to each statement accoridng to AFM 91-32. Six of the ten responses must be correct.

Define the activated sludge process and principles by matching the corect phrase or term to a statement related to activated sludge. Seven of the eleven responses must be correct.

Indicate the basic facts about activated sludge systems, by matching the proper facts to a list of various types of systems. Twelve of the seventeen must be correct.

Indicate the corrective action to take when operational problems develop by listing the proper corrective action for each problem according to AFM 91-32. Two of the four must be correct.

While visiting a municipal wastewater plant, observe the operation of the plant and equipment. Use a schematic to trace the flow and identify the components. Use a checklist to list maintenance and safety items with no more than three instructor assists.

Given information related to laboratory test controls of an activated sludge system, identify the type and reason for each test control according to AFM 91-32. Four of six must be correct.

Given information and a troubleshooting guide, identify the maintenance requirements for each activated sludge system by selecting the correct action to take. Three of the five must be correct.

Working as a team and using a schematic to operate the wastewater plant trainer, locate the correct valves to control the flow of water through each processing unit with no more than five instructor assists.

INTRODUCTION

Definition of Secondary Treatment

Waste plants discharge large volumes of water. This water normally flows into streams, rivers or lakes. You learned that the effluent from primary treatment still contains a lot of solid content. Secondary treatment is designed to further clean the wastewater so the streams will not become polluted.

Let us look at some of the units that make up a secondary treatment system. These units will be covered under the following topics:

Trickling Filter

Lagoons

Activated Sludge System

Rotating Fixed Media Biological Units

INFORMATION

TRICKLING FILTER

Basic Features of Trickling Filters

The trickling filter looks like a swimming pool full of rocks. It can be round in shape or rectangular. The bed of rocks ranges in depth from three to eight feet deep. On top of the rocks is mounted a water sprinkling system. Water is sprayed or sprinkled over the rocks and it trickles downward to an under drain system that carries the water off to another treatment unit.

PURPOSE

The purpose of trickling filters is to further treat wastewater by letting bacteria, fungi, worms, fly larvae, protozoa and algae break down the remaining waste from primary treatment.

Principles of Filter Operation

Settled wastewater is applied to the trickling filter in a fine spray. The applied wastewater trickles in a thin film over the surfaces of the filter medium which becomes coated with zoogleal film. The film contains aerobic bacteria, fungi, worms, fly larvea, protozoa, and algae. A continuous supply of food and oxygen for these organisms is furnished by the applied wastewater which is sprayed on the bed so as to absorb a maximum amount of oxygen. The film on the stones of the filter media removes fine suspended and collodial solids from the wastewater and holds them for reduction by the organisms. Since oxygen is present in the filter, a large number of aerobic bacteria will inhabit the film and work on suspended, collodial and dissolved organic solids which have become concentrated in and upon it. This brings about a reduction of B.O.D., ammonia, organic nitrogen, and especially in the lower portion of the bed, formation of nitrates. The concentration of organic matter in the film explains why wastewater is adequately treated even though only a short period of time is required for it to trickle from the top of the bed to the bottom. A new filter bed must acquire its zoogleal film before it is very efficient. The time required is usually two weeks, although this may be decreased if the filter effluent is recirculated to the filter bed.

Bacteria will reduce the amount of B.O.D. in the applied wastewater by about 50 percent in a five foot deep filter. Larger animals, such as worms, may also be present, but the zoogleal-forming bacteria are the most important. The film on the bed becomes heavy and thick at times with dead organic matter. This sloughs off to appear in the effluent as humus-like suspended matter, which still exerts some B.O.D. This sloughing off or unloading is found in all trickling filters. A bed that unloads continuously, thereby keeping worn-out film and dead matter to a minimum, usually shows a better all-time efficiency than a filter that sloughs off periodically. A thin transparent film upon the filter media indicates favorable condition. The unloading characteristics of trickling filters make it necessary to give final sedimentation to the effluent.

Bacteria and other organisms are continually active when food and oxygen are available and do not need any time for rest. The more food that is available, the more active the bacteria will be, and they only stop when the food supply stops. Thus, the upper portions of a trickling filter are more active than the lower portions in removal of B.O.D. This explains why, when trickling filters are operated in series, the secondary filter operates less efficiently than the primary filter.

Factors Affecting Filter Operation

LOADING OF FILTERS

Filter loading is expressed as either volumetric or organic.

Volumetric loading measures the volume of wastewater applied per unit of filter surface. It is expressed as millions of gallons a day per acre (mgd/acre). To determine the volumetric loading, the average flow in m.g.d. to the filter, including any recirculated effluent, is divided by the filter area in acres.

Organic loading measures the strength of the wastewater in terms of the quantity B.O.D. applied per unit of filter volume. It is expressed as pounds of B.O.D. per day per acre ft. of filter media. To determine organic loading divide the total pounds of B.O.D. applied per day by the acre ft. of filter media.

Figure 8-1 illustrates some types of filter loading.

	LOADING	
FILTER TYPES	Volumetric (mgd/acre)	BOD lb per acre ft.
Standard Rate (Low Rate)		
Normal Design	Approx 2	600
Highly Loaded	2 to 10	600 to 1,500
High Rate		
Normal Design	10 to 60*	3,000
Low Loading	10 to 60	1,500 to 3,000
High Loading	10 to 60*	3,000 to 5,000
Roughing (followed by additional secondary treatment)	10 to 60*	3,000 to 12,000

*May be above m.g.p.a.d. in some cases.

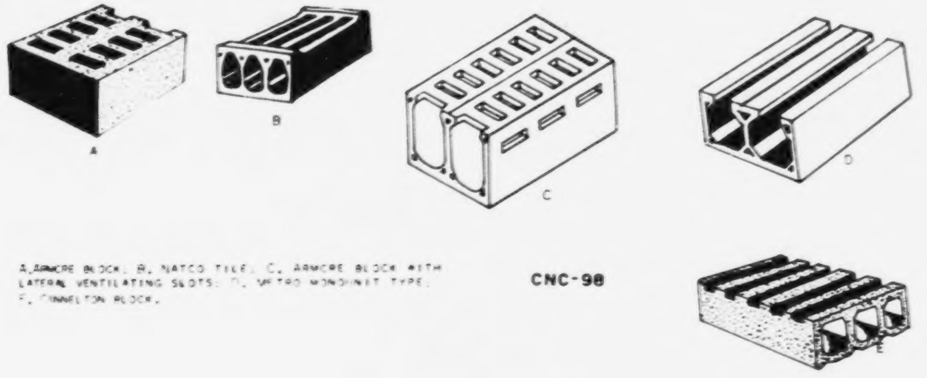
Figure 8-1. Filter Loading by Types

Efficiency of Filters

The efficiency of a filter with a normal load depends on distribution, ventilation, filter media and temperature.

Wastewater must be distributed evenly to make good use of the whole surface. Uniform flow through fixed nozzles is provided by proper dosing from the dosing chamber. As the head falls, the circle of application becomes smaller. Rotary distributors have a larger number of orifices or nozzles at the outer ends of the arms than the inner ends to cover the increased area of the larger circle. Revolving disk distributors have vanes of several sizes to give uniform application over the whole filter.

The spaces in the filter media must be kept open for good air flow. Natural air flow is up through the filter in cold weather and down in warm weather because of temperature difference between the air and wastewater. Filter underdrains must be ample in size, kept open, and their outlets unobstructed to allow the flow of air. (See Figure 8-2.) Forced ventilation of beds by means of blowers is sometimes used.



A, ARMCRE BLOCK; B, NATCO TILE; C, ARMCRE BLOCK WITH LATERAL VENTILATING SLOTS; D, METRO MONOUNIT TYPE; E, CANNELTON BLOCK.

Figure 8-2. Blocks Used in Underdrain System of Trickling Filters

The filter media must be hard and durable, free from dust, dirt or other foreign material, and all near the same size (two to four inches) throughout the filter to avoid dense spots that may cause ponding.

Filters work best in warm weather. Cold conditions in the north may drop efficiency as much as 50 percent.

Types of Filters

LOW RATE FILTERS. Standard or low-rate filters may be rectangular with fixed spray nozzles, as shown in Figure 8-3 or round with rotary distributor arms as shown in Figure 8-4. In either case, intermittent dosing is provided by a dosing tank with an automatic siphon or by a pump.

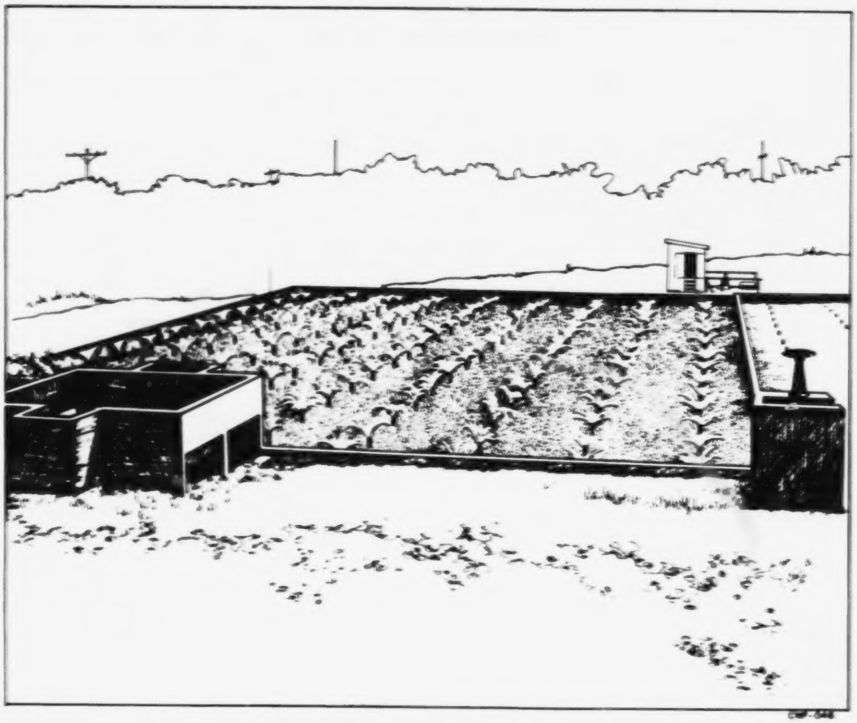


Figure 8-3 Standard Filter with Fixed Nozzles

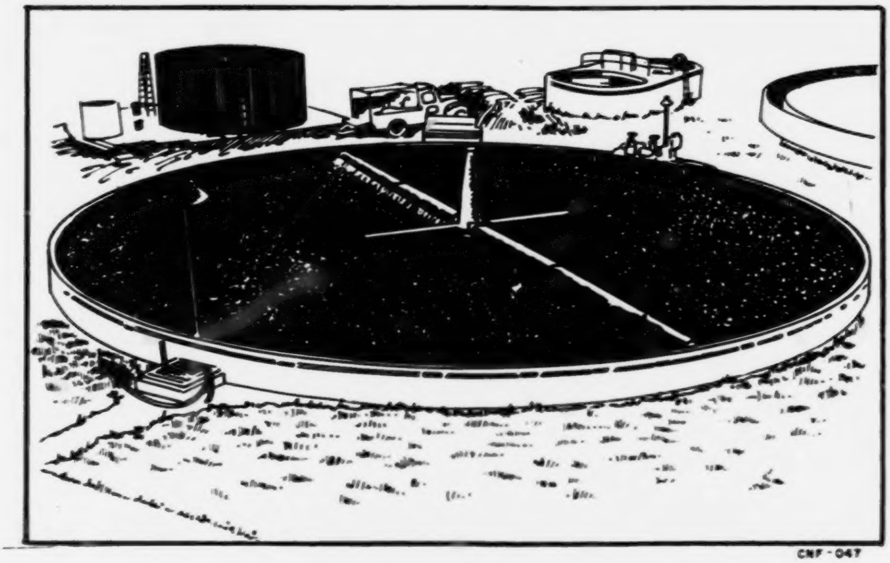


Figure 8-4. High Rate Filter with Rotary Distributor

The standard rate filter usually unloads in the fall and spring. When a change in temperature or high flow causes the bed to slough off its growth of organisms and dead matter, the filter effluent becomes turbid and frequently carries off large masses of worms found in the filter. The solids in this effluent are removed by final settling.

HIGH RATE FILTERS. High rate trickling filters are usually round in shape to accommodate the rotary distributor as shown in Figure 4 which is better for the high variations in flow than the fixed-nozzle sprays. The filter stones may be slightly larger in size than those used for standard or low-rate filters but should not exceed 4 inches in diameter. Wastewater flows continuously and a portion of the effluent from the secondary settling tanks is usually sent back to the filter with the primary settling tank effluent.

Advantages of the high-rate filter are: slightly less cost to build, less plant space used, few problems from filter flies, and less odor. Some of the disadvantages are that operation is much more sensitive, the filter can't handle a wide range of loads, the resulting sludge has a high water content and is more putrescrible, and the degree of purification is less if recirculation is not used. These factors will cause the operating cost to go up.

In high-rate filters, wastewater that has passed through the filter is recirculated either continuously or at times of low flow of raw wastewater. By this means, more volume is applied and wastewater strength is low which makes the flow on the bed more constant than for standard-rate filters. The heavy flow of wastewater will cause continuous unloading and reduce film thickness with the following effects: less fly-breeding (since more larvae are washed, this stops foul odors by freshening the wastewater), more uniform operation, the seeding of applied wastewater with active organisms and enzymes resulting in more efficient treatment with better utilization of the depth of the filter. Solids are not kept as long as in standard-rate filters, so they are less stable and continue to exert a considerable oxygen demand in settling tanks receiving filter effluent. Likewise, the solids have considerable oxygen demand and continue clarification and B.O.D. removal in settling tanks as long as aerobic conditions are kept. Nitrification is negligible with B.O.D. loads of more than 2,000 pounds per acre-foot. Settling tanks, including primary tanks if filter effluent is returned through them, are parts of high rate filter treatment.

Operational Problems/Corrective Actions

CONTROL OF PONDING. Ponding is caused by dense spots in the bed that stop flow. The condition may be caused by a large amount of suspended solids or grease in the influent; filter materials that are crumbled, dirty, or too small; excessive growth of fungi, algae, and other animal and plant forms that fill the voids between stones; or poor air flow. Ponding caused by plugged filters may be reduced or stopped by one or more of the following: (1) Flush the surface with a fire hose; (2) Rake or fork the surface stone; (3) Stop the distributor at the plugged spot and let the wastewater flow wash down the growth; (4) Punch holes in the top layer of stone with an iron bar; (5) Apply chlorine or chlorinated lime, up to 5 p.p.m. residual, to the filter influent for two to four hours each week. This should be done at night when wastewater flow and chlorine demand are low; (6) Flood the filter for 12 to 24 hours, if possible, every 7 to 14 days; (7) Allow the growth to dry by resting the filter for 12 to 48 hours if other units can be used.

CONTROL OF FILTER FLIES. The film on standard-rate filter bed stone will, at times, become infested by filter flies. The Psychoda alteranta or filter fly is a nuisance to plant operators and nearby homes. High infestation is caused by high temperatures and thick growth on stones. Filter flies can be controlled by flooding the filter for 12 to 24 hours every two weeks or by heavy doses, 2 to 5 p.p.m. of chlorine at the filter influent or dosing tank, or by changing to high rate operation.

FILTER MEDIA AND UNDERDRAINS. Keep the filter free of leaves and twigs. Any small rock or sand particles or other accumulations must be washed out of the filter underdrains and removed from the collection channels to keep them from being discharged to settling tanks where they may plug sludge lines. Keep the underdrains and channels open to let air flow through the filter. When it is cold, the filter surface must be kept free of snow and ice for proper operation of the rotary distributor. Remove bad filter stone and replace with sound stone.

ODOR CONTROL. Odors caused by decomposition of organic matter may be reduced or controlled by the following means: (1) recirculate final effluent to add dissolved oxygen; (2) reduce primary tank detention time by taking one or more tanks out of service if the detention period exceeds three hours; (3) chlorinate filter influent with dosages up to 5 p.p.m.; (4) the application of chlorine or copper sulfate to the raw wastewater at the upper ends of the system will help to keep wastewater from becoming septic, and, (5) flush sewers periodically to help deliver fresher wastewater to the treatment plant, thereby assisting in odor control.

WINTER OPERATION. In many cases, operation of trickling filters during cold weather will cause few difficulties. In extremely cold climates, however, you will need to take precautions to stop damage to equipment or interruption of the operation. In the case of rotary distributors, the drain valve in the distributor base can be opened slightly to drain and stop freezing in the distributor arms. Use of recirculation to minimize freezing at the filter by cutting down the time to the dosing cycle during low-flow periods is also used. To minimize freezing, dosing tanks are sometimes covered with planks and insulated with straw.

Final Settling Tanks

SLUDGE REMOVAL. Sludge from settling tanks following high-rate filters will turn septic more rapidly than that from standard-rate filters and must be removed at least once each shift or more often as necesary. If centrifugal pumps are used, recirculation to the primary settling tanks should be from the bottom of the tanks or the sludge removal pipe to give continuous removal of sludge.

NOTE: Read Chapter 5, for additional information on Trickling Filter, Chapter 5, Sections 1, 2, 3, 4, para. 5.1.1 to 5.4.4.

EXERCISE IV-8-8a

PART 1

INSTRUCTIONS

Using SW J3ABR56631 000-V-8 and AFM 91-32, answer the following statements.

1. What is meant by ponding in a trickling filter? ____________________________________

   ____

2. The trickling filter needs ________________ , ________________ and ________________ forms to function.

3. Odors and a black slime in the media voids will indicate that the filter is

   ________________ ________________.

4. Stones less than one inch in diameter may lead to ________________ or ________________ of the filter.

5. Trickling filter recirculation is used to increase the removal of ________________

   and ________________.

PART 2

INSTRUCTIONS

Complete the following statements using SW J3ABR56631 000-IV-8.

1. Rotary filters are designed ________________________.
2. Fixed nozzle filters are ________________________.
3. The filter depth is generally ________________________.
4. The size of the crushed rock is ________________________.
5. The proper dosing of filters is controlled by ________________________.
6. Uniform application is controlled by ________________.
7. Natural air movement in cold weather is ____________.
8. Natural air movement in warm weather is ____________.
9. A high rate trickling filter is designed to spray the filter media ________________________.
10. Following the high rate trickling filter, the final settling tank sludge should be removed at least ________________________.
11. Trickling filters have a tendency to reduce ________________________________.

a. dosing siphons
b. round in shape
c. continuously
d. 3 to 8 feet
e. each shift
f. nozzles, orifices and discs
g. 2 to 4 inches
h. copper sulfate
i. up through the bed
j. rectangular in shape
k. biochemical oxygen demand (BOD)
l. down through the filter

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

NOTE: In AFM 91-32 read Troubleshooting Trickling Filters, Chapter 5, Section 5, para. 5.5.1.

EXERCISE IV-8-8b

INSTRUCTIONS

Using AFM 91-32, correctly match the indicator with the likely cause.

INDICATOR

______1. Leaking around center column.

______2. Flow distribution not uniform.

______3. Too much ice on the surface of filter media.

______4. Black growth on media.

______5. Grease on filter media.

______6. No growth or sparse growth on media.

______7. Effluent high in BOD and suspended solids.

LIKELY CAUSE

a. Flow controls not properly adjusted.

b. Damaged or worn seal.

c. Poor ventilation - clogged underdrain.

d. Low prevailing temperature.

e. Organic loading above plant design.

f. Grease traps not serviced often enough.

g. Toxic substance in the wastewaer.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

OXIDATION PONDS

Oxidation ponds, sometimes called lagoons, holding ponds or evaporating ponds, under certain conditions, offer economical wastewater treatment and disposal. An oxidation pond is a shallow basin in which the wastewater or industrial waste is held for a period of time so that some degree of stabilization occurs. There may or may not be an effluent from an oxidation pond. Some are built so that evaporation will take place at a rate sufficient to keep all the waste in the oxidation pond. Others are designed for a continuous effluent flow.

Types of Lagoons

A lagoon is classified according to the kind of bacteria that live in it. A lagoon may contain anaerobic, aerobic, or faculative bacteria. Those lagoons which have mostly anaerobic bacteria are called anaerobic lagoons. These are used to pretreat very strong industrial wastes. The lagoons are very deep with little surface area, which reduces the amount of oxygen which can enter from the surface. Those with mostly aerobic bacteria are called aerobic lagoons and those with mostly faculative bacteria are called faculative lagoons. Aerobic and faculative lagoons are shallow with a large surface area. Most lagoons designed for secondary treatment of wastewater are faculative. These should have a large amount of dissolved oxygen near the surface and less near the bottom of the pond.

Lagoon Processes and Operations

Oxidation ponds can be used to treat industrial or domestic wastewater. They have been used for partial or complete treatment. Due to the location and design of various bases, the adaptability of oxidation ponds will vary. Wastewater plant effluent may be discharged to oxidation ponds in favorable locations such as desert or isolated areas, and where ample land is available and the climate is dry and warm.

Algae are simple one celled green plants. They and the bacteria do most of the work in oxidation ponds. The bacteria in the oxidation ponds break down the organic carbon materials in the wastewater to carbon dioxide. The algae take the carbon dioxide into their systems and give off oxygen.

In oxidation ponds, treatment is done by nature with very little help from man. If sufficient time and sunshine are provided, bacteria and algae, with the help of occasional wind action, stabilize the organic matter in the wastewater. (See Figure 8-5). Where the rate of flow is reduced on entering the oxidation pond, suspended and settleable solids will be deposited. These plus the dissolved organic mater are food for the bacteria.

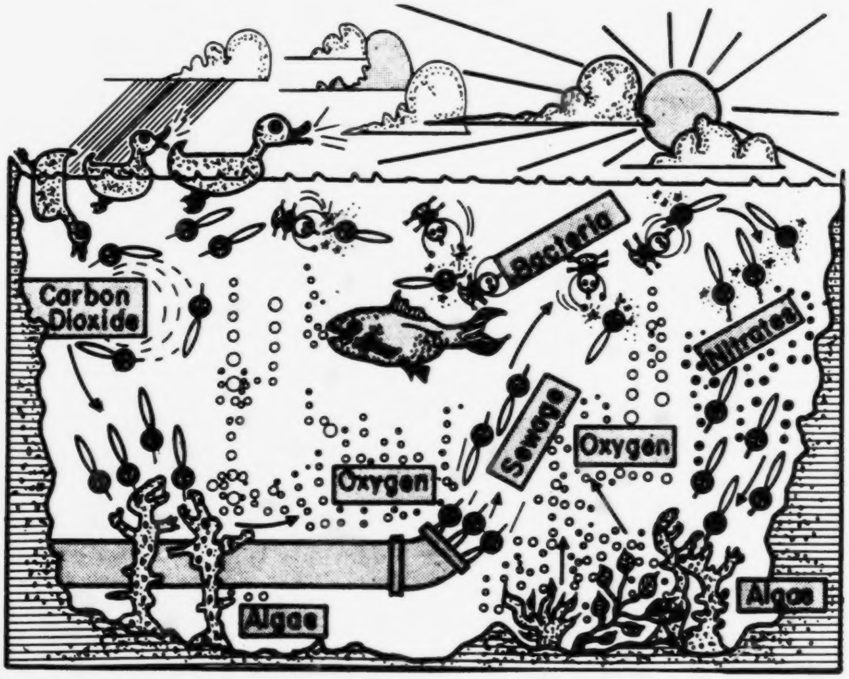


Figure 8-9. Waste Treatment in Oxidation Ponds

Biological life developed in the lagoons uses the organic and mineral matter in the wastewater for food to produce more stable products. These products often stimulate the growth of algae and other vegetation. Oxygen from the air, and the ability of vegetation to give off oxygen under sunlight help to keep lagoons aerobic. In a properly built system, aerobic conditions establish themselves after a short time. The lagoons develop an odor much the same as fresh-water ponds in the woods. In cold or cloudy weather, treatment is much less effective because algae oxygen production is retarded.

Oxygen is supplied on the surface and stirred in by wind action. Additional oxygen is made available by algae, therefore, the need for shallow oxidation ponds so that these plants may receive the sunlight they require. Bacterial decomposition of the deposited or dissolved solids furnishes carbon dioxide for the plants. In case of an overloaded pond or cloudy weather mechanical aereators may be used to increase the dissolved oxygen.

Due to the wide, shallow area exposed to the atmosphere, evaporation of water will take place. This will tend to reduce the volume of waste to be disposed of. As a result, the use of oxidation ponds is most efficient where evaporation is high. In some dry areas such loss equals the entire wastewater flow.

Primary-settling is the minimum treatment given wastewater before it is put into the lagoons. Otherwise, except under unusual conditions, sludge will build up in the influent section of the lagoons, not only causing septic conditions during digestion, but also making periodic cleaning of the inlet lagoon necessary.

When the weather is clear and warm and the pond is operated in series with other ponds, the quality of successive effluents improves as it passes from pond to pond. The amount of dissolved oxygen will often rise to the saturation point. The pH increases as the wastewater flows from one pond to the next until the effluent is definitely alkaline and the amount of B.O.D. and suspended solids fall.

Site and Construction Features

Because many oxidation ponds depend upon evaporation to dispose of the wastewater they usually work best in hot, dry climates. They also require a large land area so are usually located in isolated areas.

Oxidation ponds will be built so that the wastewater is from 3 - 5 feet deep; usually, they are not over three feet deep. If the wind is strong enough to prevent surface scum, inlet or effluent baffles may not be required. Distribution baffles are shallow so the speed of water under them is not fast enough to scour the pond bottom. It is recommended that the wastewater should flow into the center of the oxidation pond slightly above bottom. Some structures carry effluent from one oxidation pond to another. They usually provide some turbulence and aeration. Some ponds are designed to provide a minimum of 30 days detention of the average daily flow. In determining this detention period, only the top two feet of water in ponds under ten acres in area and ony the top three feet in ponds over 20 acres in area are considered. Oxidation ponds have banked edges to contain the wastewater. These banks have an inside slope of about four to one. To reduce the errosive effects of any waves due to wind, the tops and outer sides of the bands are grassed.

Maintenance of Oxidation Ponds

Keeping the area around the ponds neat and clean is very important. The dikes and walls should be kept free from brush and weeds so the pond surface will be exposed to sunlight and wind action. The growth of cattails and other weeds should be prevented. These plants attract mosquitoes and muskrats, cover the surface, and accumulate scum. Large floating objects should be removed from the pond. Mosquitoes and burrowing animals can be controlled by raising or lowering the water level about six (6) inches every two weeks. The walls of the pond should be protected from collapse or wave errosion by planting with grass or covering with rip rap.

The operator should measure the influent and effluent flow on a regular schedule to see if the design capacity is being exceeded. If the pond is hydraulically overloaded the detention time may be reduced below an acceptable level.

Just by looking at the oxidation pond will often give you a clue to how well it is operating. Some things to look for are:

- The color of the water should be slightly green with a clear effluent.
- There should be no scum or grease on the water surface.
- There should not be any offensive odors.
- There should not be any rapid changes in the water level which could indicate leakage or infiltration.

Laboratory Testing

If an oxidation pond has a discharge it must have a permit just like any other treatment plant. In this case careful records must be kept on the quality of the effluent. Your permit will tell you which tests you must run on your effluent. Some of the most common are dissolved oxygen, alkalinity and pH, suspended solids, B.O.D., sulfides and fecal coliform.

Oxidation ponds may be built to discharge a continuous effluent just as a wastewater plant does, or, if a large flat of land can be found, to rely upon evaporation to the extent that no discharge will take place. When an effluent is discharged, it will usually be lower in B.O.D. and will be higher in dissolved oxygen than the raw wastewater.

NOTE: For additional information on Lagoons, read AFM 91-32, Chapter 10, Sections 1, 2, 3, 4, 5, 6, para. 10.1.1 to 10.6.1.

EXERCISE IV-8-8c

INSTRUCTIONS

Using SW J3ABR56631 000-IV-8 and AFM 91-32, correctly complete the following statements.

1. Oxidation ponds are sometimes called ______________________________.

2. For more surface area to be exposed to the atmosphere and sunlight, oxidation ponds are ______________________________.

3. Oxidation ponds must have ____________________ to be most efficient.

4. Keeping shorelines clean and raising and lowering the water level every 10 days helps ____________________.

5. If ponds are properly operated there will be an increase of ____________________.

6. They may not have an outlet, ____________________.

7. An ______________ lagoon is used to pretreat very strong wastes such as meat packing waste.

8. Total containment lagoons are sometimes called non-discharging lagoons or ___________ ______________ ponds.

9. The lagoon area should be fenced and signs should identify it as a ______________ ____________________ ______________________________.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

THE ACTIVATED SLUDGE PROCESS

Define Activated Sludge

Activated sludge is aerobic, biological, treatment of wastewater. This system is used in secondary treatment to convert dissolved and suspended solids into settleable solids. The settleable solids may then be removed in a secondary settling tank. There are several modifications of the activated sludge system but they all work on the same principle. A well run activated sludge system can remove as much as 95% of the B.O.D. and suspended solids in the wastewater.

Description of the Process/Principles

The activated sludge system consists of aeration tanks and clarifiers or settling tanks. The aeration tanks may use either mechanical aerators or diffused aeration. The settling tanks may be rectangular or circular.

When wastewater is agitated continuously in the presence of oxygen, an active biological material known as activated sludge will be formed. This brownish floc substance is made up of numerous organisms similar to the zoogleal film in a trickling filter. Activated sludge absorbs and adsorbs dissolved and suspended organic material.

The sludge usually needs 15 to 45 minutes of contact for the adsorption and absorption of solids before biological oxidation starts.

Once the activated sludge has contacted the solids it takes several hours for the organisms to break the solids down. As the solids are broken down the activated sludge can contact more solids from the wastewater and begin breaking them down. As the wastewater leaves the aeration tank it flows into a settling tank. Here the solids will settle to the bottom and the clear water can leave the tank. The clean water may receive further treatment or be chlorinated and discharged from the plant. The solids can be recirculated to the beginning of the aeration tank where the process will start over. The sludge which is sent back to the aeration tank is called return activated sludge. All the solids in the system (aeration tanks and settling tanks) are referred to as mixed liquor. After a period of time the solids will continue to increase until there are many in the system. At this point some of them must be removed. This is called wasting the sludge. Instead of recirculating the activated sludge to the aeration tank, it can be drawn either to a digestor or directly to a drying bed depending on the type of system.

A high quality activated sludge settles rapidly and leaves a clear, odorless, stable liquid above; it is usually golden brown and has a slight musty odor. The floc usually appears to be granular with sharp edges.

A typical flow diagram of the activated sludge process is shown in figure 8-6

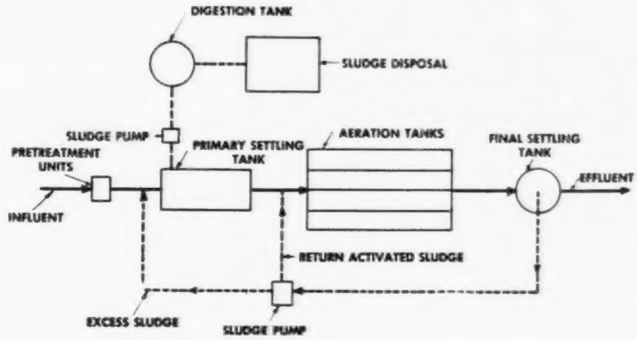


Figure 8-6. Flow Diagram of Activated Sludge Process

Description of the Equipment

Facilities for sedimentation and sludge digestion are much like those used in other treatment processes. Low head pumps and pipes for recirculating second state aerator effluent to first stage influent are often used to improve plant effluent and keep odors down.

AERATION TANKS

The main unit in the activated process is the aeration tank. These tanks use either diffused or mechanical aerators to supply air to the wastewater. Mixing of the air and wastewater causes the activated sludge organisms and the wastewater solids to contact one another and make floc. The aeration tank may be circular, rectangular or square. It should have a detention time from 0.5 hours to more than 24 hours, depending on the kind of treatment used. The aeration time is the average detention time in the aeration tanks based on the average flow of wastewater being treated by the plant plus the flow of return sludge. Aeration tanks that use diffused air, which are usually rectangular and narrow, are built to have detention time of eight hours. Mechanical aerators, generally used in square tanks arranged in series, are built for a twelve hour aeration time. Sludge is returned from secondary settling units by gravity or by a pump.

Types of Aerators

The basic factor in the activated sludge process is aeration, which is necessary to supply an adequate amount of oxygen to keep it biologically active. There should be between .5 and 2.0 mg/L of dissolved oxygen in the aeration tanks. If there is not enough dissolved oxygen the wastewater will turn septic. Septic wastewater will release hydrogen sulfide gas which smells like rotten eggs. There are two general aeration methods. These are either diffused aeration or mechanical aeration.

DIFFUSED AIR. In diffused air plants, aeration is done by the release of compressed air at the bottom of the aeration tank. This air will rise through the tank contents. Aeration tanks are designed and diffuser equipment placed so as to give a spiral motion to the mixed liquor. Methods include placing diffuser plates on the floor of the tank next to a wall over diffuser-plate boxes (see Figure 8-9); inserting diffuser tubes into the sides of a fixed air pipe along one side of the tank; attaching diffuser tube assemblies to movable pipes (swing diffusers) by which the tube assemblies may be lifted out of the tank to be cleaned (see Figure 8-7). The main parts of the swing diffuser are shown in Figure 8-8.

In diffused-air plants, air discharged through the diffuser should be controlled at both the blower and down pipes. With this control, air input can be fitted to the changing demands of wastewater strength. About 95 to 98 percent of the air keeps the tank contents in motion, mixing and causing solids to form floc; the rest of the air is used to supply the oxygen required for oxidation and stabilization. One type of blower used for providing air to diffusers is shown in Figure 8-10.

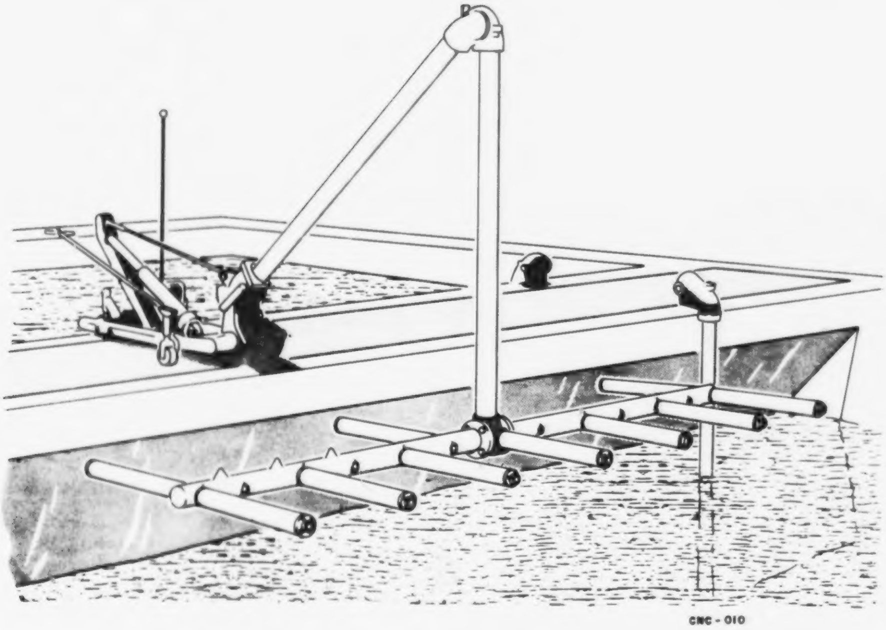


Figure 8-7. Swing Diffuser in Raised Position for Servicing

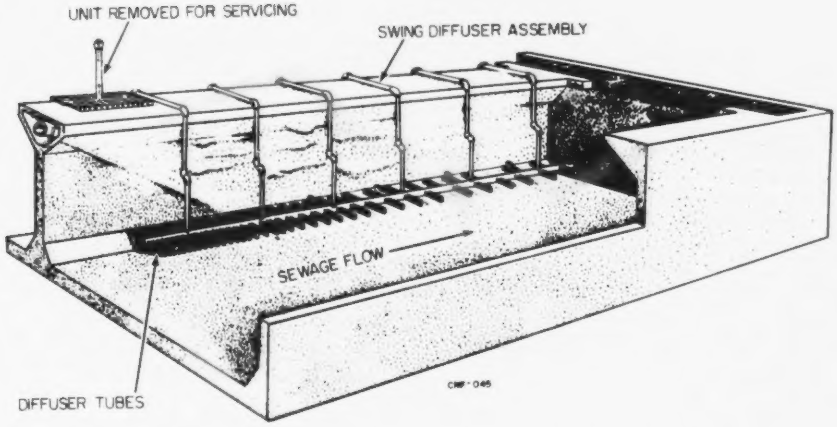

UNIT REMOVED FOR SERVICING
SWING DIFFUSER ASSEMBLY
SEWAGE FLOW
DIFFUSER TUBES
CNF-046

Figure 8-8. Cutaway of Aeration Tank Showing Swing Diffuser

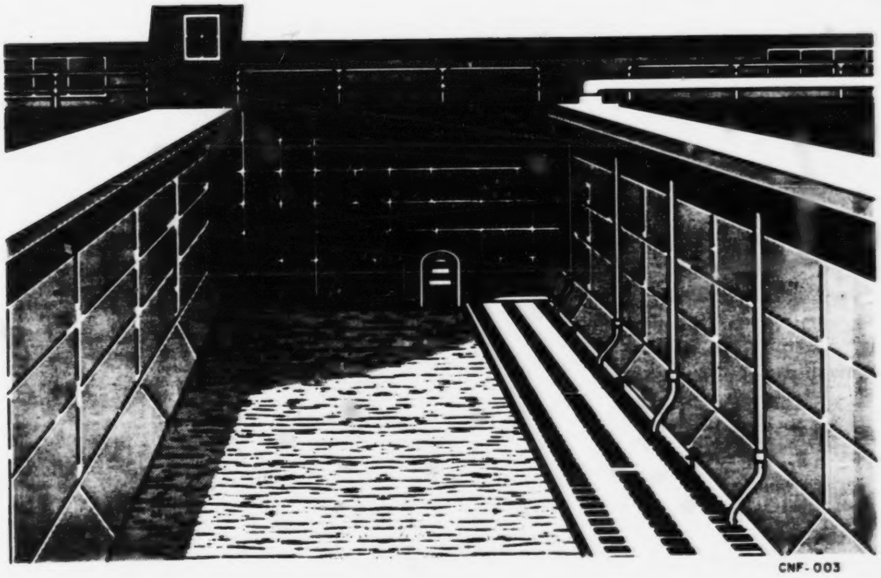


Figure 8-9. Diffuser Plates and Air Piping in a Spiral-Flow Aeration Tank

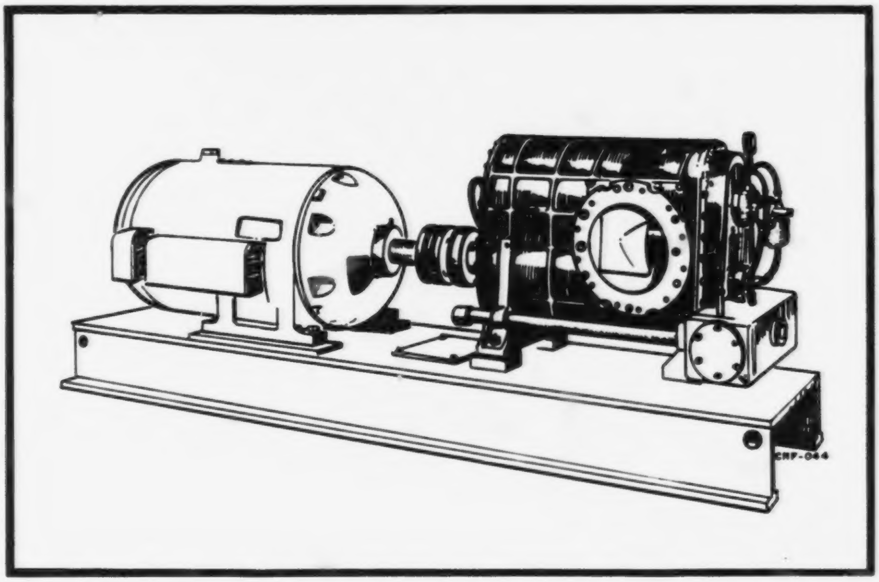


Figure 8-10. Blower Used for Air Supply to Diffuser System

MECHANICAL. Mechanical aerators use impellers, revolving disks, or brushes to spray wastewater into the air or pull air down into the wastewater.

Figure 8-11 shows equipment used to pull wastewater up through a cone from the bottom of the tank and spray it into the air. This is done by the motion of the impeller in the upper portion of the cone. Air mixed with the spray is carried downward into the tank.

Figure 8-12 shows another type of aerator which forces wastewater down in a draft tube. Air mixed with the wastewater at the funnel of the tube is pulled down and rises from the tank bottom through the wastewater.

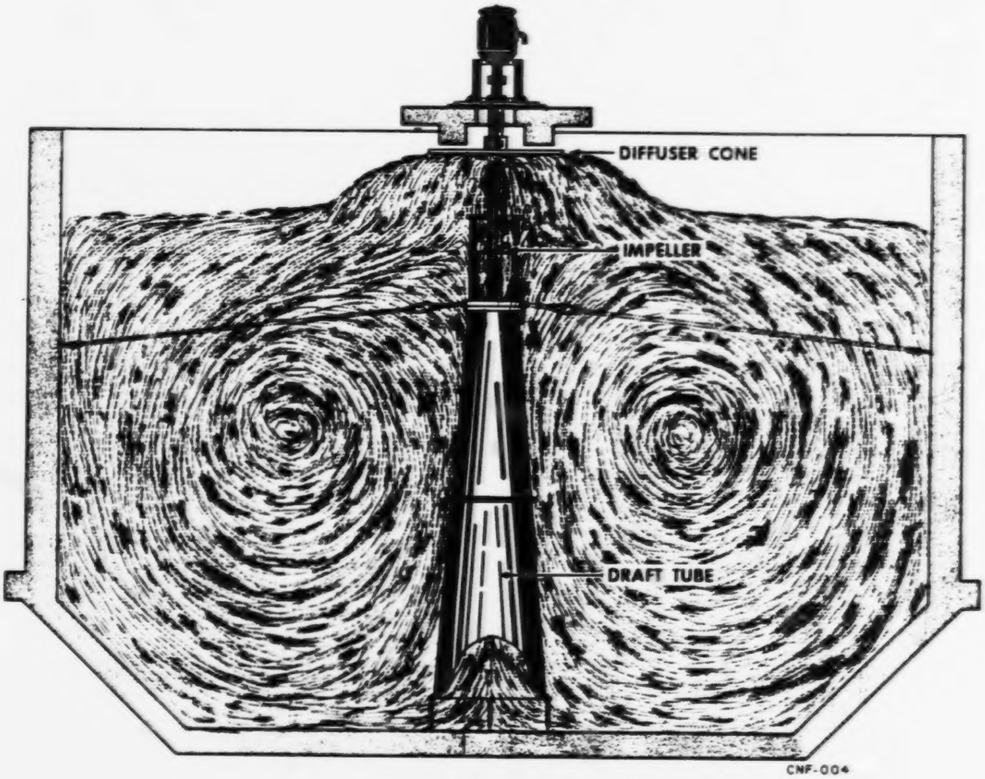


Figure 8-11. Updraft Mechanical Aerator

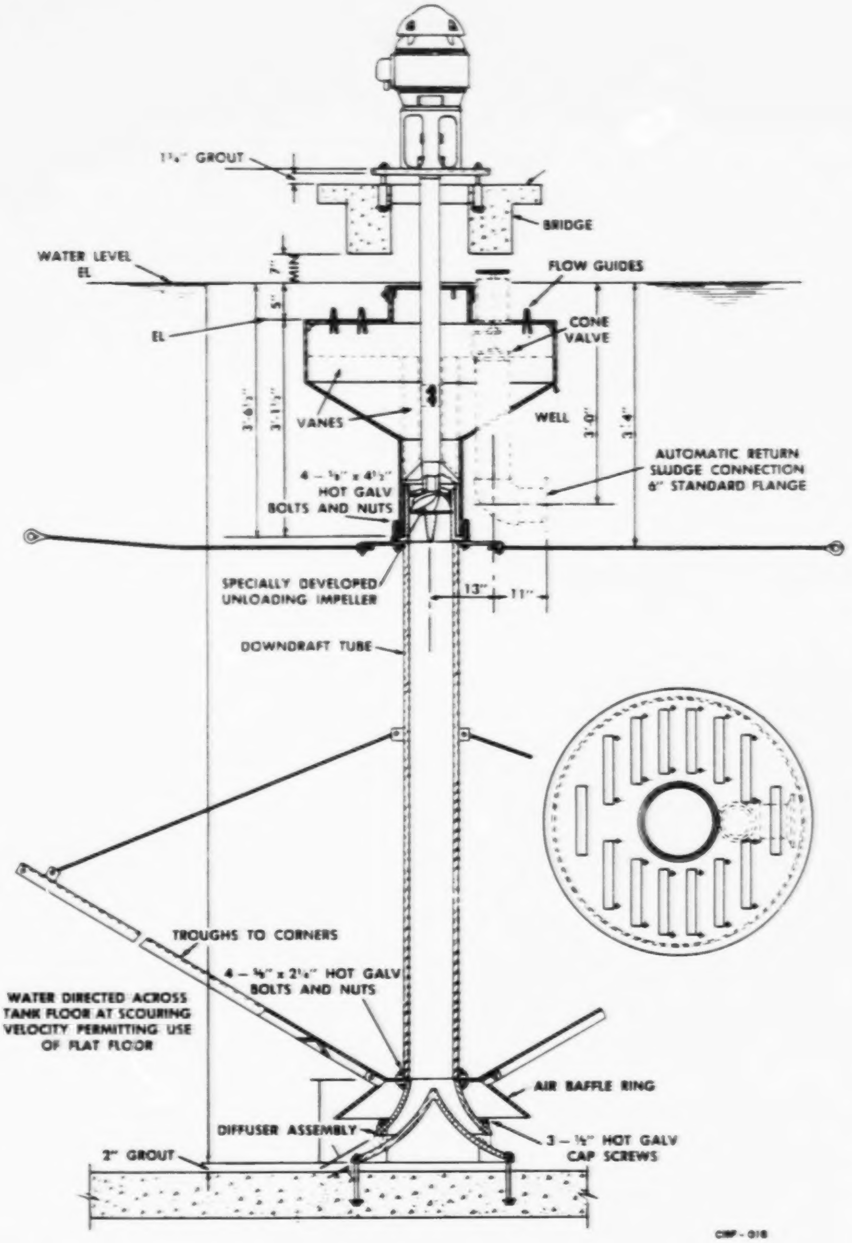

1¼" GROUT
BRIDGE
WATER LEVEL EL
7" MIN
5"
FLOW GUIDES
EL
CONE VALVE
VANES
WELL
3'-6½"
3'-1½"
3'-0"
3'-4"
AUTOMATIC RETURN SLUDGE CONNECTION 6" STANDARD FLANGE
4 – ⅝" x 4½" HOT GALV BOLTS AND NUTS
SPECIALLY DEVELOPED UNLOADING IMPELLER
13"
11"
DOWNDRAFT TUBE
TROUGHS TO CORNERS
4 – ⅝" x 2¼" HOT GALV BOLTS AND NUTS
WATER DIRECTED ACROSS TANK FLOOR AT SCOURING VELOCITY PERMITTING USE OF FLAT FLOOR
AIR BAFFLE RING
DIFFUSER ASSEMBLY
3 – ½" HOT GALV CAP SCREWS
2" GROUT
CMF-018

Figure 8-12. Downdraft Mechanical Aerator

FINAL SETTLING TANKS

Settleable solids settle in the final settling tank. Return sludge and waste sludge are pumped from the bottom of the tank. The final settling tank is not a storage tank or digestor for solids. It is used only to separate the liquid and solid by settling and to let the sludge compact before it is removed. The final settling tank may have a surface skimmer to remove floating solids and scum. The final settling tanks require about one or two hours of detention.

NOTE: For additional information on activated sludge, read AFM 91-32, Chapter 7, Sections 1, 2.

EXERCISE IV-8-8d

INSTRUCTIONS

Using SW J3ABR56631 0000-IV-8 or AFM 91-32, complete the following statements.

1. A well run activated sludge system can remove as much as ____________ of the BOD and suspended solids in the wastewater.

2. The sludge from the final clarifier which is sent back to the aeration tank is called __________________ __________________ __________________.

3. In the activated sludge system, solids are controlled either by _______________ or by ____________________ sludge.

4. The dissolved oxygen in the aeration tank should be kept between _________ and _________mg/L.

5. Odor like that of rotten eggs often comes from _______________ _______________.

6. Describe a high quality activated sludge. ______________________________________
____
____

7. Name the two general aeration methods used for the activated sludge process ______________________ and _______________.

8. Activated sludge absorbs and adsorbs ___________ and __________________________ ____________________.

9. Activated sludge is considered _________________________, ______________________ treatment of wastewater.

10. It takes about _________ to _______ minutes for the activated sludge to adsorb and absorb the solids in the wastewater.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

Conventional Activated Sludge Units

A conventional activated sludge system is very similar to a trickling filter type plant. It has preliminary and primary treatment units. But in place of the trickling filters there are aeration tanks. The sludges produced in this sytem are still very unstable and require further treatment. They need to go to some type of digestor, either aerobic or anaerobic.

Submerged Contact Aeration

Contact aeration is an aerobic process. It consists of passing settled raw wastewater through tanks that have plates of asbestos cement or other impervious materials. The surfaces of these materials become covered with zoogleal film of aerobic organisms. Air to support this organic life is blown through diffuser tubes or pipes under the contact media. The action is similar to the action in a trickling filter where biological life forms on the stones instead of plates.

A flow diagram of two-stage contact aeration plant is shown in Figure 8-13. Single-stage aeration is generally used for partial treatment only. Each aerator is divided by an overflow dividing the wall into two sections and operated in series. Each plant has air blowers and accessories for compressing air and blowing it through the diffuser or pipe system. Facilities for sedimentation and sludge digestion are similar to those used in other treatment processes. Low-head pumps and pipes for recirculating second-stage aerator effluent to first-stage influent are often used to improve plant effluent and keep odors down.

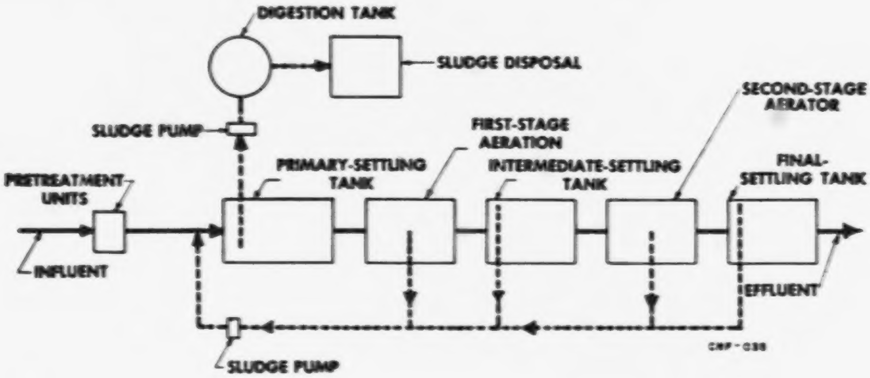


Figure 8-13. Flow Diagram of Contact Aeration Plant

The biological action in the contact aerator is the same as that in the trickling filter where organisms form a film on stones instead of plates. Biological life is also suspended in the liquor. Aerators which do not work right will have organisms that cause septic action, such as those commonly found in digesters and other anaerobic processes. Sulfur bacteria are more numerous in contact aerators than in most other secondary treatment units. When dissolved oxygen is used up and an anaerobic condition starts, aerators produce considerable amounts of hydrogen sulfide which will cause odors.

For best operation, an aerobic condition must be kept in all units following the primary settling tank. Air distribution must be efficient, plate growths must be renewed at intervals, and sludge in units following the primary settling tank must not be allowed to become septic.

Contact aeration requires the screening out of floating and suspended organic matter to protect contact surfaces. Grease and scum must also be removed to keep them from coating the surfaces and interfering with the activity in the aerator. Primary settling tanks are usually used for this purpose.

Recirculation

There is not always a need for recirculation in contact aeration except for odor control at full load. The effluent from the second stage aerator has the highest concentration of dissolved oxygen and aerobic organisms. When this liquid goes back to the inlet of the first stage aerator, this concentration of dissolved oxygen helps to meet the initial high oxygen demand and the returned organisms seed the mixed liquor and the film growth on the contact plates. This recirculation usually stops odors and gives a better treatment.

Contact Stabilization

The contact stabilization process takes advantage of the short time necessary for the activated sludge to adsorb and absorb solids. The wastewater first flows to a mixing zone or contact chamber. Here it is mixed with the activated sludge. The detention time for this tank is about 20 to 40 minutes. From here it goes to the settling zone where the activated sludge along with the solids will settle. Next the water will flow to the chlorine contact chamber and then to the plant effluent. From the settling tank the solids will go to a reaeration or sludge activation zone for 7 or 8 hours. In the reaeration zone the solids are broken down by the bacteria. The activated sludge now needs more food and is put back in the mixing zone. When there is an excess of solids they can be drawn to an aerobic digestor.

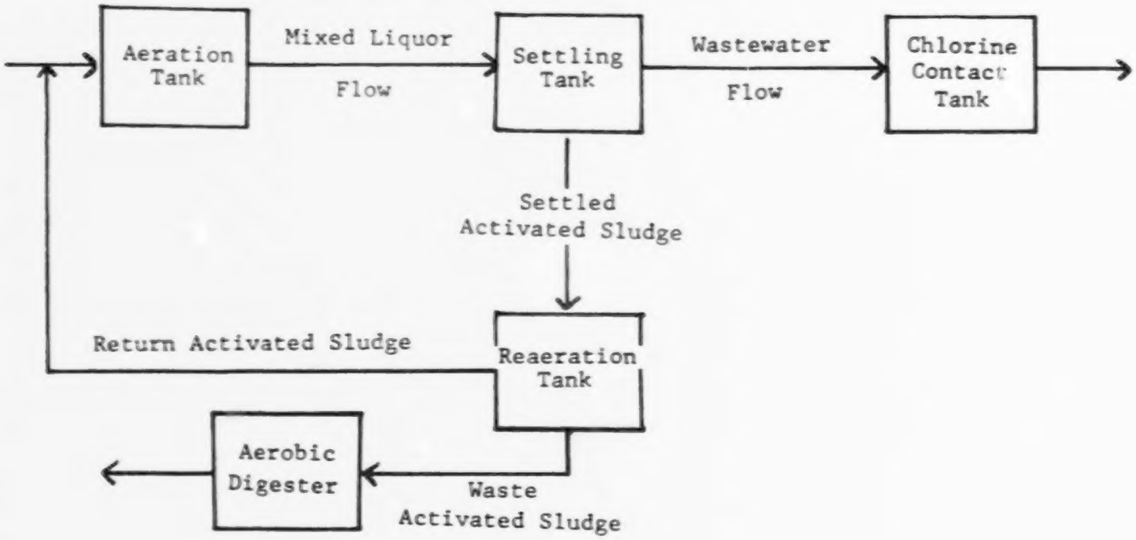

Aeration Tank
Mixed Liquor
Flow
Settling Tank
Wastewater
Flow
Chlorine Contact Tank
Settled Activated Sludge
Return Activated Sludge
Reaeration Tank
Aerobic Digester
Waste Activated Sludge

Figure 8-14. Contact Stabilization Unit

Extended Aeration

Extended aeration package plants are variations of activated sludge plants and are often used for low daily flows. They do not usually have a primary clarifier or separate sludge digestion units. The raw wastewater only goes through screening and/or grit removal before entering the aeration tank. In the aeration tank the raw wastewater is mixed with return activated sludge from the settling tank to form mixed liquor which is aerated and mixed for about 24 hours. From the aeration tank, the mixed liquor flows into the settling tanks. It will stay in the settling tank for about 1.5 to 2 hours. Each unit may consist of either two tanks, or two parts in a single tank. The suspended solids settle out of the wastewater in the settling tank. The solids are returned to the aeration tank and called "return sludge." The clear liquid at the top of the settling tank wil be the plant effluent. The extended aeration plant can remove up to 95% of the B.O.D. and suspended solids.

ROTATING FIXED MEDIA BIOLOGICAL UNITS

A rotating biological reactor is a fixed film biological treatment system using rotating plastic media. The media provides a surface on which microorganisms attached themselves and grow.

The reactor media are typically fabricated from sheets of high-density polyethylene. The sheets are bonded and assembled onto horizontal shafts up to 25 ft. long. The spacing between the sheets act as the area for the distribution of wastewater and air. The organisms that are present naturally in the wastewater begin to adhjere to the rotating surface and multiply until in approximately 1 or 2 weeks, the entire wetted surface area becomes covered with a thick biomass growth.

IDENTIFICATION OF THE PROCESS

The reactor is submerged a little less than halfway in the wastewater. As the reactor rotates, it carries the wastewater up through the reactor and absorbs oxygen from the air. Organisms in the biomass then remove both DO and organic materials from this trickling film of wastewater. More removal of DO and organic materials occurs as the media continues to rotate through the bulk of the wastewater in the tank. The speed of the reactor is 1-2 rpm.

As the reactors pass through the wastewater, some of the biomass is stripped from the plastic medium into the mixed liquor. This prevents clogging of the medium surfaces and maintains a constant microorganism population. The rotation of the reactor keeps the stripped solids in suspension until the flow of treated wastewater carries them out of the process for separation and disposal.

The biological process of the rotating biological reactors should be preceded by some form of pretreatment or primary settleable solids removal equipment. Without this equipment it may settle in the tanks beneath the media, and reduce the effectiveness of the treatment. If this does occur, it will produce a septic condition and scour biomass from the disks. Once the wastewater leaves the process the biological solids must be separated and processed as sludge. Solids separation is normally accomplished in a conventional final settling tank.

NOTE: Read the following for additional information on various types of activated sludge systems: AFM 91-32, Chapter 6, Rotating Biological Contactors, Sections 1, 2, 3, 4,para 6.1.1. thru 6.4.3; Chapter 7, Activated Sudge (AS), Section 6, Para. 7.6.1 to 7.6.7; Chapter 8, Oxidation Ditch, Section 1 thru 7, para 8.1.1 thru 8.7.5; Chapter 9, Extended Aeration (EA) and Contact Stabilization (CS) Package Plants, Section 1, 2, and 3, para. 9.1.1. to 9.3.6.5.

EXERCISE IV-8-8e

PART 1

INSTRUCTIONS

Using SW J3ABR56631 000-IV-8 and AFM 91-32, complete the following statements.

1. Contact aeration uses a biological action similar to what other unit? ____________

____

2. In contact aeration, what does the biological film grow on? ____________

____

3. If a hydrogen sulfide odor is coming from the aerator, what would be your diagnosis? ____________

____

4. In contact stabilization plants the wastewater first enters the ____________

____.

5. In contact stabilization, the mixture of wastewater and return sludge flows from the mixing zone to the ______________________________.

PART 2

INSTRUCTIONS

Using SW J3ABR56631 000-IV-8 and AFM 91-32, match the following terms to those which identify them.

______1. Secondary treatment based on return of solids from final settling tank to aeration tank.

______2. Activated sludge uses what type of bacteria.

______3. Is made up of an assembly of turning discs which are coverd by a thin growth of micro-organisms.

______4. Use primary treatment followed by one aeration tank with 8 to 12 hours detention time.

______5. Very short detention time for wastewater.

______6. All solids kept under aeration for several days.

a. aerobic

b. activated sludge

c. Contact stabilization

d. Conventional

e. Extended aeration

f. RBC

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

Plant Operation

Extent of purification depends on the right control and adjustment of the biological process. Plant operators must find the best operating range of all factors involved by systematic trial and establish procedures by study and observation to meet variable conditions. These factors include the following:

Concentration of solids in mixed liquor.

Settling rate of mixed-liquor solids.

Volume of sludge return.

Concentration of solids in return sludge.

Quantity of air required for various loadings.

MAINTAINING SYSTEMS

Aeration Tanks.

You should observe the aeration tanks for odors, colors, uneven mixing patterns and foam. If the D.O. is not maintained at a sufficient level anaerobic conditions may occur. Along with this will be a rotten egg odor. The aeration tank will normally have a brown to dark brown color, depending on the amount of solids. Black or dark gray color is caused by septic or anaerobic conditions. This is often caused by under-aeration. If an aeration tank appears to have less mixing than another, either adjust the air level or clean diffusers. Check for any problems which may cause "dead" spots in the aeration tanks. D.O. levels of less than 0.5 mg/L means that aeration should be increased. A large amount of white, sudsy foam in the aeration tank may indicate either a very young sludge age or a detergent in the system. Decreasing the waste sludge rate or not wasting any sludge for awhile should get rid of the foam if the problem is young sludge. A dense, scummy dark tan to brown foam of this type often means that the sludge has been over-oxidized. This is also called an "old sludge." This situation can be corrected by increasing the amount of sludge wasted to 20% each day until the scum stops building up.

Operation of Contact Aerators

The exact operation of all contact aeration plants cannot be given in one hard and fast set of rules since each plant is different. The following procedures should be used when operating a contact aeration plant.

When a contact aerator is placed in operation or put back in service after the plates have been cleaned, apply the primary effluent at a rate of not more than 25 percent of the normal flow. Sufficient quantities of air must be diffused into the aerator to form a heavy growth on the plates. When a dissolved oxygen concentration of 1 p.p.m. is obtained in the first stage, gradually raise the flow and air input until you get full flow, keep the D.O. of 1 p.p.m. and 3 p.p.m. respectively. Air valves should be set to send approximately two-thirds of the air to the primary aerator. If adequate D.O. concentrations can be kept, one or more blowers can be cut off during low flows.

Make sure air is distributed evenly through the contact area of the tank, and air pressure readings should be recorded. Air by-passing any part of the contact surface will cause dead spots and anaerobic growths. Clogged holes in the air distribution grid are stopped by blowing out the grid daily. At plants with overhead air distribution, drop pipes can be disconnected at the union for removal and cleaning of perforated pipe.

Note and record growth characteristics on contact plates. For this purpose, removable observation plates of asbestos cement are placed in each of the aeration sections between the contact plates. The color of the growth shows its oxidizing power; a brown thin film is best with a grayish thin film next. A black film or any underlying black portions show a septic action which is bad. An odor of hydrogen sulfide (rotten egg) will also tell you that a septic action is taking place in the process. The heavy growths or biologically dead or inactive film must be cleaned off of the contact plates. Once these organisms die, they are no longer of any use. They are then removed from the contact plates with high pressure air.

Aeration Tanks

Aeration tanks are construction of reinforced concrete or steel and are left open to the atmosphere. The total aeration tank volume required should be divided among two or more units capable of independent operation. Individual tanks should have inlet and outlet gates or valves so that they may be removed from service for inspection and repair.

If the tank is to be aerated with diffused air, the proportioning of the tank may significantly affect the aeration efficiency and the amount of mixing obtained unless the type, number, and location of diffusers are properly chosen.

To ensure efficiency of the diffusers, the depth of sewage in the tank should be between 10 and 15 feet. The width of the tank in relation to its depth is important if spiral flow mixing is to be used. The width to depth ratio for such tanks may vary from 1 to 1 to 2 to 1. This limits the width of a tank channel to between 15 and 33 feet. For tanks using diffusers on both sides or with diffusers in the center of the tank, greater widths are permissible. The important point is to restrict the width of the tank so that dead spots or zones of inadequte mixing can be avoided.

Adjusting Aeration Tanks. Aeration periods of eight hours for diffused aeration and 12 hours for mechanical aeration are best. Adjustment to conform to factors discussed above improve plant operation. In mechanical aeration tanks at small installations, maintaining dissolved oxygen in first stage of aeration is often difficult. Small diffuser units are used to boost the oxygen supply.

RATE OF RETURN. The volume of activated sludge returned from final settling tanks to aeration tanks will normally range from 20 to 40 percent of the raw wastewater flow. A high rate of return reduces the aerator detention time but it keeps the sludge fresh and it may return needed dissolved oxygen to the aerator inlet. A low rate of return will raise the aerator detention time. This low return rate is feasible when the sludge has a low rate of oxygen use and does not readily turn septic. A high return sludge concentation is obtained with low return rate.

Secondary Clarifier.

By checking the plant effluent and looking at the final clarifier surface, the operator may decide when process changes are needed. The effluent from a final settling tank in an activated sludge plant should be clear and almost free of suspended solids. Another item of concern is bulking sludge. This means that the solids do settle well from the water. Some of these solids will rise to the top of the clarifier and pass over the discharge weir.

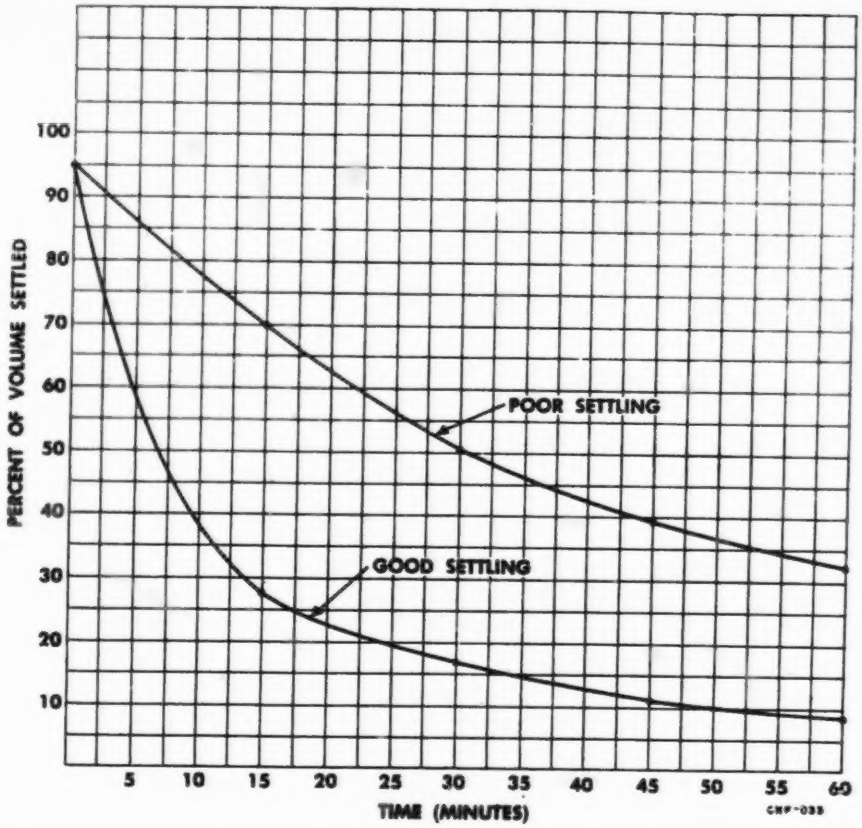


Figure 8-18. Curves Showing Conditions of Activated Sludge

Tests. Control tests for mixed-liquor and return sludge, suspended solids, and settled volume are made daily or preferably once each shift.

DISSOLVED O_2. Although most of the oxygen dissolved in the mixed liquor during aeration is used by the activated sludge, it is only two to five percent of the oxygen supplied to the tanks. Air requirements are governed by B.O.D. loading, quality of sludge, and solids concentration of mixed liquor.

Control. In diffused air plants, air application is usually controlled by blower combinations or variable output blowers. Air supply in mechanical plants is governed by the number of units in service and automatic time switches on each aerator.

Tests. Make dissolved-oxygen tests daily or preferably each shift, on samples of the mixed liquor from the inlet end, middle, and outlet end of the aerators. An inhibitor is used in collecting dissolved oxygen samples to slow down bacterial action and oxygen use; otherwise, you will get low test results. These tests show whether or not air supply is satisfactory. If one p.p.m. of dissolved oxygen is present at the inlet and progressively builds up to four or five p.p.m. at the end, air supply is right.

Excessive Application. Too much air will cause waste and may cause the flocculent sludge to be finely dispersed and difficult to settle. Much of it will pass over the settling tank outlet weirs.

AERATION PERIOD. Approximately 80 to 85 percent of wastewater purification takes place in the first hour of aeration. During the rest of the period, sludge is regenerated, organic matter stabilized, and sludge conditioned for further activity. The sludge's capacity to take in organic matter is limited and regeneration is necessary before an additional load is applied. Activated sludge needs oxygen at a definite, measurable rate. It absorbs oxygen from the water as rapidly with only a few p.p.m. in solution as when the water is near saturation.

Sludge age

To determine the sludge age or the average length of time the solids have been in the aeration tank you divide the pounds of solids in the aeration tank by the pounds of suspended solids added each day.

$$SA = \frac{\text{weight of MLSS in aerator}}{\text{weight of suspended solids added to the aerator daily}}$$

Mixed Liquor Suspended Solids (MLSS)

The suspended solids which is run on the aeration tank mixed liquor is called the mixed liquor suspended solids test. It is used as a control test to help find out whether to increase or decrease the rate of sludge return or help us decide when to waste sludge.

$$MLSS = \frac{\text{weight of dry solids x 1,000}}{\text{Sample volume (ml)}}$$

SVI/SDI

The sludge volume index and the sludge density index relate the weight of the sludge to the volume it occupies when it has settled. Good quality sludge should have a SDI between 1.0 and 2.5. It should have a SVI between 40 and 150.

$$SVI = \frac{{}^{ml}/l \text{ settable solids (30 min)}}{{}^{mg}/l \text{ suspended solids}} \times 1,000$$

$$SDI = \frac{100}{SVI}$$

Microscopic

An activated sludge plant will work best when certain organisms are prevalent. By examining a sample of the mixed liquor under a microscope we can see if they are. If other organisms are present they may forewarn the operator of problems and allow him to correct them before they become serious.

Maintaining Systems

Concentration of solids. The aeration tank mixed liquor should have at least 10% settleable solids by volume. When the sludge concentration reaches or goes above 70% settleable solids by volume, it is best to waste or remove some of the sludge. However, the concentration in the aeration tank should never be reduced below 10%. The best level is 30% to 50%. The concentration of sludge can be checked by settleability test. Test results and daily checks will show whether small amounts of sludge should be wasted often or whether larger amounts should be wasted less often.

Aeration Tank. The mixed liquor in the aeration tank should appear medium to dark brown with little or no foam on the surface. If the mixed liquor is dark gray or black, the system may not have enough D.O. and could be septic. In this case, the D.O. should be increased to at least 0.5 mg/L.

RATE OF WASTE. A division is usually used to split the flow of returned sludge from the final settling tank to waste or to aeration tank influent. Suspended solids concentration in the aeration tank and return sludge determine when and how much sludge goes to waste. Schedules must be developed for wasting sludge in small amounts each day, holding the solids in the aeration tank at a nearly constant level. Sludge is wasted slowly and uniformly, generally during the periods of low flow. The rate of waste sludge is normally about ten percent of the return sludge.

FINAL SETTLING TANK. Because settled sludge must be kept fresh for return to the aeration tanks, the sludge blanket in the settling tank is held to less than two feet. Mechanical sludge collection equipment must be operated continuously. Hoppers are squeegeed often to free them of septic sludge. Hose down walls, weirs, and channels each day. Rising sludge which is black on the underside shows that sludge is sticking on the walls or floors; these areas must be kept free of accumulated sludge.

Operating Difficulties

Operating difficulties are usually one or a combination of three conditions; the presence of oil or grease; bulking sludge; and disposal of supernatant from the digester.

OIL AND GREASE. Oil and grease from mess halls or laundry wastes harm bacteria growth in the aeration tanks. The sources of grease and oil are eliminated by proper cleaning of grease traps and oil interceptors. Primary-settling tanks are kept skimmed off.

BULKING SLUDGE. A sudden loss of sludge density shown by poor settling, passage of floc through the final-settling tanks, and increased sludge index is known as bulking. It occurs in two forms: A large diffused floc resulting from loss of biological balance and a light floc containing sphaerotilus, a microscopic threadlike fungus growth. Bulking may be caused by the following: Solids concentrations in the aeration tank too high or too low, low air supply, short aeration period, and sudden heavy loads on the system such as a heavy dose of strong digester supernatant or an overload of stale or septic wastewater solids flushed to the plant by rains after a long dry spell, wastewater abnormally high in organic solids, especially sugars and starch, or fungus accumulations from the sanitary sewer system may likewise cause bulking sludge.

When bulking results in septic aeration units, you may need to waste the sludge and redevelop a good floc. In the early stage of bulking, reconditioning is aided by increasing sludge return and amount of air. Fungus growths can usually be controlled by chlorinating the return sludge in doses of 1.0 to 8.0 p.p.m.

Rising sludge in final-settling tanks is usually caused by an excessive retention period which forms gas which (in turn) lifts the sludge in chunks. Increasing the sludge return rate to lower the sludge blanket stops the trouble. This condition may also be caused by nitrification brought on by excessive aeration.

EFFECT OF DIGESTER SUPERNATANT. Digester supernatant disposal in the activated sludge plant is troublesome, especially when the digester is not working well. Supernatant is usually returned to the plant influent where it passes through the entire plant process. Being well seeded with the organisms of anaerobic digestion, it tends to increase the septic action in the settling units. If discharged intermittently while the sludge is being pumped, it throws a big load on the secondary process. If the mixed liquor is not in condition to take this load, the sludge soon turns gray and septic.

Supernatant is returned as uniformly as possible.

Returning it directly to the aerator often eliminates the difficulties.

Returning it to the aerator during low loadings sometimes is successful.

If the supernatant is returned intermittently, the solids in the mixed liquor must be in condition to receive it (higher in concentration). The D.O. must be watched with care and increased during the period if necessary.

Sludge should be drawn from intermediate and final settling tanks at four-hour intervals and returned to the raw wastewater flow. To avoid septic conditions, squeegee sludge from the hoppers each day.

Wash down walkways and brush influent and effluent channels each day.

If two or more intermediate settling tanks are used, keep only enough tanks in service to provide 1-1/2 hours detention time at the average daily rate of flow.

Dissolved oxygen concentrations in the effluent from each aerator section and in intermediate and final settling tank effluents should be checked each shift. The B.O.D. and suspended solids test on composite samples of raw wastewater and of primary, intermediate, and final effluents should also be made.

Proper Concentration. The concentration of mixed liquor solids for best operation under all conditions must be found for each plant by trial. Aeration solids concentrations of 1,200 to 3,000 p.p.m. in diffused-air plants and 500 to 1,200 p.p.m. in mechanical plants are usual, but they may be varied to suit seasonal or plant load conditions.

INFORMATION

NOTE: Read AFM 91-32, AFM 91-32, Chapter 7, Activated Sludge (AS), Sections 2, 4, 5, para 7.2.1 thru 7.2.6.4, 6.4 thru 7.5.5.

EXERCISE IV-8-8f

INSTRUCTIONS

Using AFM 91-32, chapter 7 complete the following statements.

1. The main unit in the activated sludge process is the ____________________.

2. With the diffused air system __________ ____________ is forced into the bottom of tank near one side.

3. Mechanical aeration devices may have a __________ or __________ bridge.

4. Forced air supply equipment consists of __________ __________ and ________.

    ____________ valves are used to protect the equipment from too much pressure.

5. Centrifugal blowers often have ____________, ____________, ________ or lobes to move the air.

6. The final settling tank may have a surface skimmer to remove ______________

    ______________ and ______________.

7. The operator should observe the aeration tanks for __________, _________,

    __________ ____________ __________ and foam.

8. If the plant is working right, it will smell ____________________.

9. __________ ____________ may cause the mixed liquor to take on other colors.

10. Organic overloads may use all the ____________ and cause the aeration tank

    to become ______________.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

NOTE: Read AFM 91-32, Chapter 7, Activated Sludge (AS), Section 3, para. 7.3.1 thru 7.3.10.

INFORMATION

Field trip to municipal wastewater treatment plants.

EXERCISE IV-8-8g

PART 1

INSTRUCTIONS

Complete this exercise while on Field Trip. List the safety items that were observed.

Burkburnett -

1.

2.

Iowa Park -

1.

2.

Electra -

1.

2.

PART 2

INSTRUCTIONS

Using the schematics of the municipal wastewater treatment plants provided to you, complete each one by the end of the Field Trip.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

EXERCISE IV-8-8h

INSTRUCTIONS

Using AFM 91-32, Chapter 7, Section 3, complete the following statements.

1. The sludge blanket should not be allowed to rise above ________________ the depth of the final clarifier.

2. If solids are not wasted, ________________ or ________________ they will be discharged in the effluent.

3. F/M ratios and sludge age are often used to test for the right amount of __________ in the system.

4. Sludge Volume Index (SVI) and Sludge Density Index (SDI) show the amount of

   ____________ produced and the way the sludge will ________________.

5. Knowing the sludge return rate will help the operator keep the right amount of

   ________________ ________________ in the aerator mixed liquor.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

Read AFM 91-32, Chapter 6, Rotating Biological Contactors, Section 3, Troubleshooting Guide; Chapter 7, Activated Sludge (AS), Section 5, Troubleshooting Guide; Chapter 8, Oxidation Ditches, Section 7, Troubleshooting Guide; Chapter 9, Extended Aeration (EA) and contact stabilization (CS) Package Plant, Section 3, Troubleshooting Guide.

EXERCISE IV-8-8i

PART 1

INSTRUCTION

Using AFM 91-32, Chapter 7, Troubleshooting Guide, match the indicator with the likely cause.

Indicator	Likely Cause
______1. Septic condition in primary clarifier.	a. Septic anaerobic condition
______2. White fluffy foam in aeration tank.	b. Detention time too long.
______3. Hydrogen sulfide (H_2S) odor around aeration tanks.	c. Not enough suspended solids in the tank.

PART 2

INSTRUCTIONS

Using AFM 91-32, Chapter 9, Section 3, Troubleshooting Guide, match the indicator with the likely cause.

Indicator	Likely Cause
______1. Fluffy, poor settling sludge in the settling tank.	a. The air lift pump is clogged
______2. pH not in right range - about 6.5 to 8.5.	b. Improper aeration
______3. Bubbles rising in the clarifier.	c. Concentrated industrial waste
______4. Unusual vibration in the skimming device or air lift pump.	d. Septic condition
______5. Sludge not being pumped by air lift pump.	e. Breakdown of unit, out of adjustment

PART 3

INSTRUCTIONS

Using AFM 91-32, Chapter 8, Section 7, Troubleshooting Guide, match the indicator with the likely cause.

Indicator	Likely Cause
______1. Eddies or quiet areas in the ditch.	a. Worn or damaged speed reducer
______2. Rotor unit not working.	b. Wrong sludge return rate
______3. Rotor unit noisy, vibrating or heating.	c. Abrupt bends at ends of ditch
______4. Irregular jerking motion of the clarifier sludge collection device.	d. Over or under lubricated
______5. High level of sludge in the clarifier, solids passing over the discharge weir.	e. Failure of electrical controls

PART 4

INSTRUCTIONS

Using AFM 91-32, Chapter 6, Section 3, Troubleshooting Guide, match the indicator with the likely cause.

Indicator		Cause
______1. Loss of biomass.	a.	Low wastewater temperature below 55°F
______2. Decreased efficiency (BOD and suspended solids)	b.	Organic overload sustained
______3. Large areas of white biomass on the RBC media.	c.	Grit removal unit not working right
______4. Plant effluent too high in BOD and suspended solids.	d.	Toxic substance in wastewater
______5. Buildup of solids in the RBC compartments (tanks).	e.	Septic wastewater high in hydrogen sulfide (H_2S) content

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

This objective will be covered using the wastewater trainer.

EXERCISE IV-8-8j

INSTRUCTIONS

Using the wastewater treatment trainer, a checklist and a schematic of a wastewater plant, correctly locate the valves that control each process.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

Secondary treatment of waste water is a further decomposition from the primary treatment. There are several units that can be used in the secondary treatment process. You may find some plants using all or a part of them.

Trickling filters are made up of circular or rectangular tanks filled with rock. Primary effluent is sprayed over the rock and bacterial action further reduces the waste products.

Oxidation ponds are the simplest form of treatment. Under certain conditions they offer economical treatment and disposal. Their use is suited to warm, dry climates.

In the activated sludge process, air is mixed with the wastewater in an aeration tank. Since aerobic bacteria are used, then air is necessary for them to live. Regulation of the air supply is very important to the activated sludge.

Contact aeration is basically an aerobic biological process. It consists of passing settled raw wastewater through aeration tanks. Air to support organic life is blown through perforated pipe. Biological action is similar in some respect to that in trickling filters.

REFERENCE

AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

3770th Technical Training Group
Sheppard Air Force Base, Texas

SW J3ABR56631 000-IV-9

TERTIARY (ADVANCED) TREATMENT

Given a list of incomplete statements and a list of terms and phrases related to advanced wastewater treatment, select the correct term or phrase that pertains to each statement. Seven of the ten selections must be correct.

Given information and a troubleshooting guide and four problems, list one corrective operational or maintenance procedure for a phosphate tank, denitrification unit and carbon filter IAW AFM 91-32. Two of the four procedures must be correct.

INTRODUCTION

Much has been written over a period of many years about the need to control pollution. More recently, there has been a rapid rise in interest in treating wastewaters for more direct and deliberate reuse. The advanced waste treatment research program of Public Health Service has begun to develop and demonstrate practical means of treating municipal wastewater and other waterborne wastes to remove the maximum amounts of pollutants. The purpose of this is to restore and maintain the nation's water at a quality suitable for repeated reuse.

The current terms "tertiary treatment" and "advanced waste treatment" are being used to describe a great variety of wastewater treatment processes which range from simple ponds used to polish secondary effluents to complex demineralization schemes. The materials found in secondary effluents which are of concern in most pollution control programs are suspended solids, B.O.D., bacterial concentrations, phosphates, and nitrogen. Where direct water reuse is being considered, removal of soluble nonbiodegradable organic materials and dissolved solids may also be necessary.

The processes discussed in this study guide will be limited to some of the main ones; where secondary treatment is inadequate for removal of B.O.D., suspended solids, phosphate, and nitrogen.

Tertiary treatment will be discussed under the following main topics:

Principles Of Tertiary Treatment

Methods Of Tertiary Treatment

PRINCIPLES OF TERTIARY TREATMENT

INFORMATION

Tertiary treatment is the third stage of treatment for wastewater (tertiary means the third part). Physical, chemical or biological treatment may be used. Here is a list of some tertiary treatments:

- plain sedimentation
- chemical precipitation
- filtration
- ion-exchange
- activated carbon
- electrodialysis
- reverse osmosis
- ammonia stripping
- stabilization ponds
- coagulation
- chemical oxidation
- phosphate precipitation
- denitrification
- polishing lagoons

Tertiary treatment can be just about any process used after normal secondary treatment.

A good primary and secondary treatment reduces B.O.D. and suspended solids by 90 percent. To cut into that last 10 percent, other methods are used. No one method of tertiary treatment is best for all plants, because each plant has its own problems and capabilities. More than one of the treatment methods in the list above may be used to meet the requirements of a specific plant. The cost of the process determines which one will be used.

METHODS OF TERTIARY TREATMENT

Tertiary treatment is usually used when the treatment plant effluent is to be reused. What the effluent is to be used for determines the quality standards it must meet. Sometimes B.O.D. plays a part, but more often other characteristics are more important. For example, an effluent that contains large solids or tends to develop slimes could not be used for a cooling system. Depending on what the effluent is to be used for tertiary treatment may be needed to correct problems with the hardness, the concentration of some mineral or ion, the pH or the turbidity as well as other characteristics.

Filtration

Sand filters, coal filters, and microstrainers have been enhancing the quality of secondary effluents for years. Following good secondary treatment, plain filtration (filtration without the addition of chemical coagulants) can remove most suspended solids with B.O.D. This makes the effluent suitable for many industrial uses.

D-E Filtration

Studies have been made on diatomaceous earth (D-E) filtration of secondary effluent. Where D-E was fed at a controlled rate to the effluent which is then passed through a precoated filter septum, it was found that D-E filtration produced a final effluent with no detectable B.O.D. and only a trace of suspended solids. The major problem associated with D-E filtration is its inability to tolerate significant variations of suspended solids concentrations. A filter run of only ten minutes can occur during periods of high solids, making this process very costly. Even if the secondary effluent turbidity can be maintined at less than 100 units, it has been estimated that the operating cost alone will be 7.5 cents per 1000 gallons, exclusive of the cost of disposing of the spent filter cake. The following discussions will show that other means of effluent filtration can be provided at much lower costs.

Microstrainers

Microstraining is another process that may be used for tertiary treatment. A recent study has shown that a microstrainer with openings of .001 inch could remove an average of 89 percent of the suspended solids found in the secondary effluent. A microstrainer with .0015 inch openings would remove 73 percent. Caution must be observed about the adverse effect of grease and high secondary effluent solids content. The estimated cost of microstraining is about 1.5 cents per 1000 gallons for a plant treating 10 mgd.

One reported problem concerning the ability of a microstrainer to handle wide fluctuations of solid loadings was that an increase in secondary effluent suspended solids from 25 to 200 mg/l caused the output of the strainer to drop from 60 to 13 gpm in a few minutes. As with D-E filtration, microstraining alone does not provide reliable tertiary treatment because it is not capable of handling the variations in suspended solids which occur in most secondary plants.

Slow Sand Filters

Slow sand filters have been used for polishing of secondary effluents. In addition to requiring very large land areas and considerable maintenance, they have been found to be ineffective due to rapid clogging of the filters.

Filter Media Distribution

It is apparent from the above information that filtration of secondary effluents is a difficult problem. The variations in effluent quality which adversely affect D-E filters, microstrainers, and slow sand filters also have an adverse effect on rapid sand filters.

The sensitivity of a rapid sand filter to high suspended solids concentrations can be readily understood by looking at Figure 9-1. Figure 9-1 illustrates a cross-section of a typical single-media filter, such as a rapid sand filter.

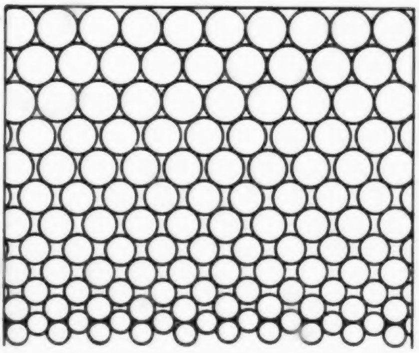


Figure 9-1. Rapid Sand Filter

Most of the material removed by the filter is removed at or very near the surface of the bed. When the secondary effluent contains relatively high solids concentrations, a sand filter will clog at the surface in only a few minutes. As would be expected from the grain size distribution illustrated in Figure 9-2, 75 to 90 percent of the headloss occurs in the upper one inch of the rapid sand beds when filtering activated sludge plant effluent.

One approach to increasing the effective filter depth is the use of a dual-media bed with a discrete layer of coarse coal above a layer of fine sand, as shown in Figure 9-2. The work area is extended, although it still does not include the full depth of the bed, as there is some fine to coarse stratification within each of the layers. Effective size of the sand in a typical dual filter is 0.4 - 0.5 mm.

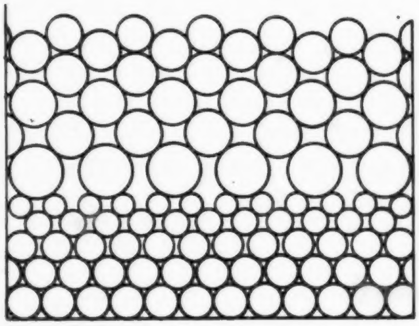


Figure 9-2. Coarse Coal Above Sand

It has been found that grain size is of major importance in determining how efficiently the filter removes suspended solids. The effluent should pass through as fine a filter material as possible. This presents a serious inconsistency in design of a dual-media bed, as shown in Figure 9-2. It would be desirable to have the coal as coarse as is consistent with solids removal to prevent surface clogging. The sand needs to be as fine as possible to provide maximum solids removal. However, if the sand is too fine in relation to the coal, the sand will actually rise above the top of the coal during the first backwash and remain there when the filter is returned to service. For example, if a 0.2 mm sand were placed below 1.0 mm coal, the materials would actually reverse during backwash, with the sand becoming the upper layer and the coal, the bottom layer. Although the sand has a higher specific gravity, its small diameter, in this case, would result in its rising above the coal at a given backwash rate.

Mixed-Media Bed

To overcome the above problem and to achieve a filter which closely approaches an ideal filter is illustrated in Figure 9-3.

The problem of keeping a very fine media at the bottom of the filter is overcome by using a third, very heavy (garnet, specific gravity of about 4.2) very fine (0.15 mm) material beneath the coal and sand. The resulting mixed-media filter has particle size graduation which decreases from about 1 mm at the top to about 0.25 mm at the bottom. This filter has a coarse upper layer to reduce sensitivity to surface clogging but forces the effluent to pass through a much finer media than does either a sand or coal-sand bed. The

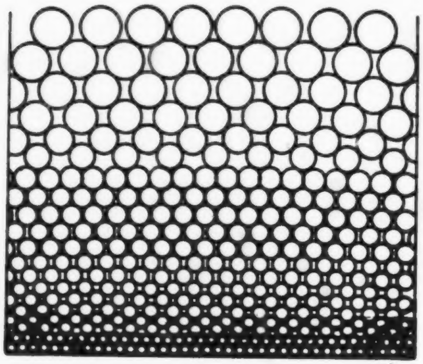


Figure 9-3. Coarse Too Fine

uniform decrease in particle size with filter depth allows the entire filter depth to be utilized for floc removal and storage. This discussion describes the effluent quality achieved by mixed-media filtration from a properly designed activated sludge plant. The B.O.D. is less than 5 mg/L; and turbidity less than 5 units. The cost of this application of mixed-media filtration (including both capital and operating costs) is about one cent/1000 gallons.

Although a mixed-media filter can tolerate higher suspended solids loadings than can the other processes discussed, it still has an upper limit of applied suspended solids at which economically long runs can be maintained. With suspended solids loadings up to 120 mg/L, filter runs of 15 to 24 hours have been maintained. Solids concentrations of 500 mg/L or more will lead to uneconomically short filter runs, even when using a mixed-media filter. A reliable tertiary filtration system will require either a secondary effluent of uniformly good quality, or some intermediate treatment to reduce any extremely high solids concentrations prior to filtration. Since the former is very unlikely, mixed-media beds have been developed to permit supplementary filtration of secondary effluent with a minimum of space and cost.

Coagulation and Sedimentation

Coagulation and sedimentation alone can reclaim water suitable for many uses, and they can also prepare secondary effluents for even higher degrees of treatment. The cost is primarily dependent upon the coagulant dose required. Generally, greater quantities of coagulant are necessary to precipitate phosphates than for effective turbidity removal. For example, an alum dose of 25 mg/L may produce excellent coagulation and minimum turbidities but it will reduce the phosphate content only slightly. To remove most of it requires about 150-200 mg/L of alum. Lime doses are usually about twice as great to obtain the same results, but since the price of lime is only half that of alum, costs are comparable.

Efficient coagulation and settling of a good quality secondary effluent will provide a final product with a turbidity of 1 to 2 units. Suspended solids and B.O.D. will be less than 5 mg/L. Phosphates can be reduced to 1 or 2 mg/L by using enough coagulant.

Chemical coagulants, such as aluminum sulfate and ferric chloride are added to wastewater for the primary purposes of removing setteable solids and phosphorus. These chemical additions will cause reductions in heavy metal build-up and improve disinfection of the wastewater.

The process involves three separate operations. The first method is injection and mixing of the coagulants that neutralize the negative charges on suspended matter. The second one is coagulation of particles into large settleable floc. The last one is sedimentation in open tanks to provide gravity separation of the flocculated material from wastewater. The amount of chemical coagulant that you need to achieve a good coagulation varies with time and from wastewater to wastewater.

Large doses of coagulants yield massive quantities of chemical sludge; however, recovery and reuse are more economical than disposing of the sludge and purchasing new coagulant. Recent studies prove that lime recovery and reuse are feasible.

Filtration and Coagulation

To remove nearly all of the particulate matter requires the filtration of the chemically coagulated effluent. Settling must precede filtration with the use of conventional rapid sand filters. If chemically treated secondary effluent were applied directly to a conventional filter, the surface would quickly seal. Only by using mixed-media filters is it possible to eliminate the need for settling of the chemical floc. However, if frequent and severe upsets of the secondary clarifier occur; it is best to provide settling prior to filtration.

At a 2.5 mgd water reclamation plant at Lake Tahoe, the coagulated and filtered effluent (no settling) had a B.O.D. less than 1 mg/L of C.O.D. (chemical oxygen demand) of 20 to 60 mg/L, a phosphate content of 0.1 to 1.0 mg/L, a color of 10 to 30 units, a turbidity of 0.1 to 1.0, and a coliform content of less than 2.1/100 ml following chlorination. No viruses were present. Even with the chemical doses necessary for phosphate removal, the high degree of treatment costs only $80 to $100 per million gallons for a 10-mgd plant. When lower doses are satisfactory, cost may dip to $20 to $30 per million gallons.

Adsorption

Activated carbon is an effective adsorbent. Other materials are also adsorbent in nature but none is as effective as carbon for many classes of organic substances. When municipal waste water is passed through beds of granular carbon or when granular carbon is slurried with the effluent, the removal of 70 to 95 percent of the C.O.D.-bearing organic materials are eliminated. The carbon treated effluent is clear and nonfoaming. The organic materials escaping carbon are believed to be largely colloidal.

Activated carbon has a network of "micropores" which can adsorb a large amount of matter. The fact that activated carbon has an extremely large surface area per unit weight makes it a very efficient adsorptive material. Because of this, as the water is passed through the activated carbon, much of the organic material is removed. Once the pores are full of organic material the activated carbon can be regenerated by heating it at 800°C - 900°C. This will burn off the organic material and the carbon can be reused.

The principal factors in the use of activated carbon for treating municipal effluents are listed below:

1. Carbon reactivation is necessary to reduce costs to acceptable levels. Thermal regeneration has been proven practical.
2. Pretreatment of the secondary effluent ahead of the activated carbon may be required.
3. 0.5 to 1 lb of carbon will treat 1,000 gallons of secondary effluent.
4. Preliminary cost projections for reduction of 50 to 70 mg/L of C.O.D. to 10-15 mg/L are from 5-10 cents/1,000 gallons of wastewater for plants larger than 10 mgd.
5. Inorganic salts are not removed by carbon.

Electrodialysis

Electrodialysis has the capability of reducing the concentrations of inorganic solids in water and is already a commercially proven process. The brackish water source of Buckeye, Arizona, for example, is converted to a usable supply by electrodialysis.

Studies have shown that inorganic ionic materials in waste effluent can be reduced by electrodialysis on a relatively nonselective basis. The feed to the electrodialysis process should be nearly free from organic contaminants. Suspended solids must also be at a very low level to avoid physical plugging of the electrodialysis cells.

Some of the significant findings on electrodialysis of municipal wastewaters have been as follows:

1. 6-10 kwh/1,000 gallons is the estimated power required to remove 300-500 mg/L of solids.
2. Product to waste volumes of 10:1 can readily be achieved and 50:1 has been accomplished.
3. Total cost for electrodialysis will vary with the amount of materials removed. Preliminary estimates indicate that 15-20 cents/1,000 gallons may be the range for municipal effluents. This cost does not include allowance for necessary pretreatment or for ultimate disposal of the brine concentrate.

Chemical Oxidation

We know from past studies that oxidation is a process involving an increase in positive valance or a loss in electrons. An oxidizing agent gains its electrons. In the process of corrosion, oxidation of iron by chlorine and hydrogen sulfide is a lot of times common in wastewater. Wastewater and industrial wastes contain or produce compounds and gases that attack metallic and, in small amounts, non-metallic materials. Among the causes of corrosion are the formation of hydrogen sulfide in anaerobic decomposition and the presence of alum solutions, lime, ferric sulfate and ferric chloride solutions and fatty acids in wastewater.

Oxidation-reduction reactions are ones involving transfer of electrons.

Example:

$H^{+}{}_{2}S^{=} + Cl^{\circ}{}_{2} \longrightarrow 2\ H^{+}Cl^{-} + S^{\circ}$

$2\ Fe^{++} + Cl^{\circ}{}_{2} \longrightarrow 2\ Fe^{3+} + 2\ Cl^{-}$

$H^{+}{}_{2}S^{=} + 4Cl^{\circ} + 4H^{+}{}_{2}O^{=} \longrightarrow H^{+}{}_{2}SO^{=}{}_{4} + 8H^{+}Cl^{-}$

In the first example shown above, hydrogen sulfide, an obnoxious gas, is oxidized by free chlorine and removed from the system. Sulfur is produced. In the second example Fe^{2+} a soluble ion, is oxidized to Fe^{3+} which can easily form $Fe(OH)_3$ and precipitate out. With this in mind we can say that oxidation is loss of electrons and reduction can be the gain of electrons.

In the examples shown, chlorine, the oxidizing element, gains electrons and is said to be reduced. In the first example, the reducing agent, sulfur, and in the second example Fe^{2+}, lose electrons and so are oxidized. In this case we can say oxidation reduction occurs in the same reaction. Note in each of the first two reactions that the $^{+}$ and $^{-}$ charges of the equations balance. The third equation is included to show an additional oxidation equation by chlorine which removes H_2S.

Air Stripping

Aeration involves exposing as much water surface as possible to the air. During aeration, gases dissolved in the water supply are released to the atmosphere. Aeration raises the pH by doing away with dissolved carbon dioxide but increases corrosiveness by increasing the amount of dissolved oxygen. Aeration in wastewater helps get rid of ammonia, hydrogen sulfide and in some cases chlorine.

Nitrogen Removal

The units for providing nitrogen removal are all based upon the principle of biological nitrification and denitrification. There are a variety of treatments for applying these basic concepts.

The ion exchange approach gives good nitrogen removal under many conditions without adding dissolved solids. The cost and investment is the highest of all three units. The breakpoint chlorination process is very good as it removes all of the ammonia. It can be used in either summer or winter conditions and can adjust to changes in flow. It has been suggested that it be used as a polishing step in a series with other nitrogen removal methods.

Nitrogen, Total, Organic and Ammonia Processes

Total nitrogen in wastewater is divided into four forms: organic-N, ammonia-N, (NH_3) nitrate-N (NO_3^-) and nitrite-N, (NO_2^-).

Normally, primary and secondary treatment will remove most of the organic-N by settling and converting it into the ammonia-N form. Any additional removal is accomplished by advanced treatment.

The most common or abundant form is organic-N in the form of NH_3 and NH_4^+. Ammonia-N is corrosive and raises the pH of water. It has a pungent odor, is toxic to life in the receiving stream and to us in high concentrations. It can result in a disease in infants known as blue babies.

Ammonia-N puts a great oxygen demand on the waterways due to its nitrification process. The organic-N originates from body wastes, animal and human, (NH_3 and NH_4^+). To remove the ammonia from wastewater we can use the nitrification/denitrification process, stripping, ion exchange or breakpoint chlorination.

To use the nitrification/denitrification process we must first remove the H+ from NH_3 or NH_4^+. The form in which ammonia will be present depends on the pH of the wastewater. If the pH is above 7.0, most of it will be ammonia; below 7.0 it will be mostly ammonia ion. During the nitrification process the ammonia -N (NH_3) is converted to nitrates or nitrites. This is accomplished through the plant for normal removal or additonal systems are designed and constructed to remove all the ammonia-N under the nitrification process. Nitrification is an aerobic conditioning process usually accomplished at the last part of secondary treatment where B.O.D. is at its lowest levels. Keep in mind that only the form of nitrogen is changed, not the elimination or reduction of concentration of nitrogen. The treatment units used can be either a high rate trickling filter or extended activated sludge system. Once the ammonia is removed by the aerobic bacteria, the oxygen demand of the receiving stream will be less. At this time, if the remaining nitrates and nitrites are safe to be released into the stream, nitrifcation is accomplished.

The following are examples of nitrification:

$$NH_3/NH_4^+ + O_2 \longrightarrow NO_2^-$$

$$NO_2 + O_2 \longrightarrow NO_3^-$$

The NO_2^- and NO_3^- forms are not toxic to the receiving stream, but these are still considered nutrients or food for organisms which can cause etrophication for premature aging of a stream. This is when the vegetation will grow in large amounts, robbing the oxygen from the stream causing septic and anaerobic conditions.

Denitrification is the process of removing the nitrogen from the wastewater by changing the form from $NO_2/NO_3 \longrightarrow N + O_2$. The nitrogen-N is released as a gas and the oxygen-O_2 is used by the various aerobic organisms for respiration purposes. Therefore, the oxygen is "stripped" from NO_2 and NO_3 leaving N_2 to be dispersed as gas.

These gas formations will usually occur in the final settling tank. Enough gas will cause sludges to rise forming floating mats and unsightly appearance.

Denitrification must have certain favorable conditions: the nitrogen must be in the NO_3^- or NO_2^- form, no D.O. present but must have some B.O.D. present. The pH should be 6.5 to 7.5. The temperature should be about 68°F. The lower the temperature, the less reaction will take place.

The system used for denitrification may be anaerobic ponds, anaerobic tank systems, or anaerobic filters. Most plants add organic matter to the process, such as methonal or glucose. The organic matter should be inexpensive and create a low sludge volume.

Another way to remove nitrogen is in the form of ammonia gas. This is called ammonia stripping. As the pH of wastewater is raised above 7.0 the ammonium ion forms ammonia gas. Lime can be added to raise the pH of the wastewater to about 11. Then the ammonia gas can be stripped with air by means of cooling towers and air blowers. This process works best in warm weather.

Further information pertaining to nitrogens can be read in AFM 91-32, pages 14-17 to 14-25.

Polishing Lagoons

Polishing lagoons are ponds that get wastewater from a treatment plant. Most of them are made by forming dams across ravines and dry creeks whose shape, depth, and surrounding area are not controlled. Most lagoons have been built for the treatment of organic industrial wastes and wastes from animal feed lots. In a lagoon it is very important that the carbon-nitrogen-phosphorus balance of the waste be such that the process can be successful. Most of the time there isn't a shortage of carbon in most industrial wastes. But sometimes industrial wastes have very little nitrogen or phosphorus.

It has been the practice of some vegetable and fruit canning plants to put their discharge into lagoons, then once the organic load reduction takes place, to send the discharge to a river. In all properly operating lagoons, a dense growth of green algae makes oxygen. Then the aerobic bacteria oxidize the organic carbon and change it to carbon dioxide. Then the algae, through photosynthesis, converts much of the carbon dioxide to algae cell material. The pond effluent then may contain as much organic material as the wastewater entering it. The wastewater entering the lagoon is hazardous to the community's health but the effluent is highly stable. The effluent then may be of much value in promoting the growth of fish and other wildlife.

NOTE: For additional information of Advanced Wastewater Treatment (AWT) read Chapter 14, Advanced Wastewater Treatment (AWT), Section 1 thru 7, para. 14.1.1 thru 14.7.3.

EXERCISE IV-9-9a

INSTRUCTIONS

Using SW J3ABR56631 000-IV-9, and AFM 91-32, complete the following statements.

1. Define tertiary treatment.

2. What is the purpose of tertiary treatment?

3. List three main principles of tertiary treatment.
   a.
   b.
   c.

4. List five tertiary treatment processes.
   a.
   b.
   c.
   d.
   e.

5. What is the reason for the special arrangement of media in the mixed bed filter?

6. List two disadvantages of D-E filter.
   a.
   b.

7. Name four impurities that can be reduced by tertiary treatment.

a. ______________________________ c. ______________________

b. ______________________________ d. ______________________

8. The organic materials escaping carbon are mostly ______________________.

9. Phosphorus can cause heavy growth of algae and other plants and can result in

____________ ____________, ____________ and other problems.

10. Dissolved and colloidal organics can be removed by ____________ onto

______________________________.

11. High levels of nitrate-N in drinking water can result in a serious disease in

____________ known as ____________ ____________.

12. Denitrification systems downflow filter needs frequent ______________ and

____________ to remove trapped nitrogen gas.

13. Denitrification is the reduction of ____________ to ____________ and then to

____________ gas.

14. In downflow contactors, the entire contents of the lead contactor should be removed

for ______________________.

15. Phosphorus can be removed by using coagulants such as ____________, ____________

____________ and ____________.

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

INFORMATION

NOTE: Read the following information in Chapter 14, on troubleshooting guide for Advance Wastewater Treatment (AWT), Chatper 14, Advance Wasterwater Treatment (AWT), Section 8, Para. 14.8.1.

EXERCISE IV-9-9b

INSTRUCTIONS

Using AFM 91-32, Chapter 14, Section 8, Troubleshooting Guide, match the indicator with the likely cause.

Indicator

______1. Chemical feed units not operating.

______2. Chemical feed units running but no chemical being fed (delivered).

______3. Poor floc formation in floccualtion tank.

______4. Low quality effluent from filter units, too many suspended solids and short filter runs.

______5. Decreased efficiency in the activated carbon unit. Too many suspended solids in the effluent.

______6. Decreased efficiency in nitrification/ denitrification units.

Cause

a. Wrong operating procedure

b. Adsorptive capacity of the carbon used up

c. No electric current being supplied to the unit

d. Wrong pH range

e. Filter media not thoroughly backwashed or media may need to be replaced

f. Clogged pump, screen or pipe

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

The term tertiary treatment means third-stage treatment for wastewater. It is used primarily for polishing secondary plant's effluent. The principles used may be physical, chemical or biological in nature.

Some processes used are plain sedimentation, chemical precipitation, filtration, activated carbon adsorption, carbon filters, air stripping, phosphate precipitation tank, denitrification units and polishing lagoons.

REFERENCE

AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

3770th Technical Training Group
Sheppard Air Force Base, Texas

SW J3ABR56631 000-IV-10

DISINFECTION PROCESS

OBJECTIVE

Given a schematic of a wastewater plant, identify the points where chlorine may be applied and complete written statements related to wastewater disinfection. Ten of the fifteen completed statements must be correct.

INTRODUCTION

The need for wastewater disinfection cannot be overstated. The increasing population and the growing demand for water supplies lead us to consider sources that were not suitable years ago. With the population increase comes more need for swimming areas and also more bodies of water to receive wastewater plant effluents. Chlorination is used to disinfect final effluents, control odors, and to protect our sources of water.

Chlorine may be obtained as a liquid or gas, or a hypochlorite solution.

The information regarding chlorination of wastewater will be presented in this study guide under the following main topics:

Pre-chlorination

In-plant chlorination for operational control

Post-chlorination

PRE-CHLORINATION

Pre-chlorination is the adding of chlorine to wastewater as it enters the plant. Disinfection of raw wastewater without further treatment is not practical because of limited effect of chlorine on large solids as well as being expensive.

Low Flows

Pre-chlorination may be used to keep wastewater fresh and prevent odors when flows are below the rate for which the treatment plant was designed and detention periods in settling tanks are excessive. The amount of chlorine required depends on how putrid the wastewater is when it reaches the plant. A dosage up to 5 ppm, even without residual, is usually effective.

Odors

Chlorine acts immediately on hydrogen sulfide gas to prevent odor. The influent to trickling filters may also be pre-chlorinated to control odors. This is usually done only when prevailing winds are in the direction of inhabited areas. Elimination of foul odors from sewer systems and teatment plants throughout the year is increasingly difficult. With the rapid growth of population and expansion into rural areas more people are concerned with this.

IN-PLANT CHLORINATION FOR OPERATIONAL CONTROL

In some areas of plant operation chlorination is used. This type of chlorination is neither pre- nor post-chlorination but is defined as in-plant chlorination.

Filter Control By In-Plant Chlorination

Ponding of trickling filters can often be corrected by applying heavy doses of chlorine to the filter influent. A residual up to 5 ppm applied 3 or 4 hours daily for several days causes the solids to crumble and fall away from the filter rocks. Application is best made at night when wastewater flow and chlorine demand are low.

Filter flies can be controlled somewhat by chlorination to a residual of 2 to 5 ppm for several hours at 2 week intervals. Care must be taken not to decrease filter efficiency by destroying bacterial growth.

Activated Sludge Control

Chlorine may be applied to return activated sludge to correct bulking caused by fungus growths. The dosage depends on the solids content of the sludge; over chlorination must be avoided because it may effect the biological life in the activated sludge.

Chlorination may be started by applying approximately 1 ppm (based on return sludge flow) and increasing the dosage daily by small amounts until a slight turbidity is noted in the final tank. Dosage should then be decreased. In most cases the maximum dose should not exceed 8 ppm.

If a bulking has been continuous or continues to reappear whenever chlorination is stopped, a small amount of chlorine applied continuously (after bulking has been remedied by heavier chlorine dosage) may help to maintain a low sludge index. In some cases this may also be accomplished by continuous low chlorine dosage of the incoming raw wastewater.

POST-CHLORINATION

Post-chlorination is chlorination of wastewater plant final effluents to reduce bacteria and B.O.D.; it is used when it is necessary to protect the receiving stream. Determination of the necessity to use post-chlorination is made by the major air command.

Disinfection of Plant Effluents

Disinfection is generally necessary when wastewater effluents are discharged to bodies of water used for domestic water supply, reproduction of shellfish, recreation of training activities, and irrigation. Disinfection may be regular as when supplies are endanged, or seasonal as when the stream is used for swimming. During rainy seasons or periods of high run off, disinfection may not be necessary because of the increased dilution of wastewater by heavy flows. Because chlorine demand and wastewater flow will vary, the chlorine residual of the effluent should be checked hourly so the rate of chlorine feed may be adjusted.

Complete sterilization of wastewater is not practicable or economically feasible, but the reduction of bacteria count in settled or treated wastewater effluents is as high as 99.5 percent following chlorination for a 15 minute contact period with a residual of 0.3 to 0.5 ppm. This residual will usually kill all types of disease-producing bacteria and insure effective disinfection.

A 15-minute contact detention period is necessary to provide time for chlorine to contact and kill organisms. This may be in a separate contact chamber baffled to prevent short circuiting (see Figure 10-1) or in the outfall sewer if it is long enough.

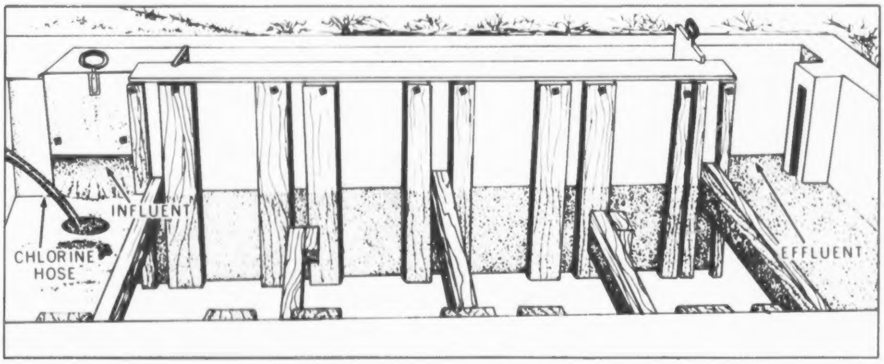


Figure 10-1. Chlorine Contact Tank

Reduction of B.O.D.

Each ppm of chlorine added to wastewater effluent reduces B.O.D. in the receiving stream by 1 to 2 ppm. This B.O.D. reduction is effective in preventing septic conditions or low dissolved oxygen content in a stream where the dilution factor is low. The effect is low however if there are sludge banks in the stream below the outfall.

For post-chlorination to protect receiving streams, a chlorine residual up to 0.5 ppm is adequate although higher residuals may be required during low stream flows. Post-chlorination is not a cure-all for poor stream conditions and cannot replace proper wastewater treatment and correct operations.

NOTE: For more information, read Chapter 11 on Disinfection, AFM 91-32, Chapter 11, Disinfection, Section 1 thru 6, para. 11.1.1 thru 11.6.1.

EXERCISE IV-10-10a

PART 1

INSTRUCTIONS

Using SW J3ABR56631 000-IV-10 and AFM 91-32, complete the following statements.

1. Why is chlorine added to wastewater? ______________________________

____

2. Define pre-chlorination? ______________________________

____

3. Define in-plant chlorination? ______________________________

____

4. Define post-chlorination? ______________________________

____

5. How long a contact period is required to provide time for chlorine to contact and kill organisms? ______________________________

6. The most common forms of chlorine used in wastewater treatment are:

   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________

7. Chlorine containers should be stored away from:

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

8. Do not touch the valve with the ______________, when checking for leaks in connections.

9. What are two types of gaskets used when connecting lines together?

a. ______________________________

b. ______________________________

10. What gas is produced by putting a high voltage electric charge to pure or enriched oxygen or air? ______________________________

11. What chemicals are good disinfectants and are used in industrial treatment, and other fields?

a. ______________________________

b. ______________________________

c. ______________________________

12. What are the most costly disinfectants used in wastewater treatment?

a. ______________________________

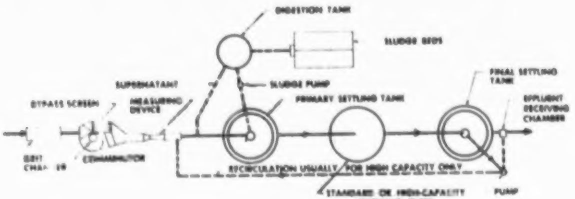
b. ______________________________

13. Instructions for operation and maintenance of chlorination equipment is provided by the ______________________.

PART 2

INSTRUCTIONS

Look at the schematic below, then answer the following questions.


DIGESTION TANK
SLUDGE BEDS
SUPERNATANT
SLUDGE PUMP
FINAL SETTLING TANK
BYPASS SCREEN
MEASURING DEVICE
PRIMARY SETTLING TANK
EFFLUENT RECEIVING CHAMBER
GRIT CHAMBER
COMMINUTOR
RECIRCULATION USUALLY FOR HIGH CAPACITY ONLY
STANDARD OR HIGH-CAPACITY TRICKLING FILTER
PUMP

1. On the schematic above, place a PrC at the point where prechlorination would be applied.

2. On the schematic above, place an IP at the points where an in-plant dosage of chlorine could be used.

3. On the schematic place a PoC at the point where post chlorination would be applied.

4. How much contact time should be allowed after post chlorination before discharging the effluent into a stream?

5. What is your reason(s) for selecting the site(s) for in-plant dosage?

6. What dosage would you suggest using at the site or sites you selected?

7. Under what conditions would you suggest using prechlorination?

8. Approximately how many P.P.M. dosage would you suggest for prechlorination?

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

Chlorine is used in wastewater disinfection and odor control. It comes in several forms but is commonly used in the gaseous state. Pre-chlorination is the application of chlorine to wastewater as it enters the plant inlet while post-chlorination is accomplished by chlorinating the final effluent to reduce bacteria and B.O.D.

REFERENCE

AFM 91-32, Operation and Maintenance of Domestic and Industrial Wastewater Systems

3770th Technical Training Group
Sheppard Air Force Base, Texas

SW J3ABR56631 000-IV-11

LOGS AND REPORTS

OBJECTIVE

Given pertinent data about a wastewater plant and AF Forms 1462 and 1463, complete the forms. Four of the seven entries must be correct.

INTRODUCTION

Records and reports are essential tools which are necessary for operation and maintenance of wastewater plants and facilities. They provide essential data on plant design, equipment, and operations. They are used at the operator, management, and engineering levels. Regulatory agencies use tham to evaluate plant operations and insure that permit requirements are being met. Records and reports provide a way using past experiences, to determine current and future needs. They are also valuable tools for training new personnel.

INFORMATION

Equipment and Facilities

A complete set of records and plans of the sewage system and wastewater treatment plant are filed at the plant or in the installation engineer's office. The records include the following:

1. Dates of installation and major additions.

2. Data of design and capacity of sewers, pumping stations, and treatment plants.

3. Pump data, including manaufacturer, type, size, capacity and head.

4. Manufacturer's data on all installed mechanical equipment.

5. File of test and operating records.

Records kept for a long period of time are the best means of indicating effects in changes in population, seasons, and wastewater plant operating procedures. Records are also an aid in designing plant extensions. A record is kept on lift stations from day to day. You want to make a check of the pumps, air compressors, pipes, valves, recording charts, and other equipment that is at the lift station. You can make a check of your equipment and lift station every two hours. You should sign the log and initial the blanks that pertain to your equipment. (See Figure 11-1). If you have any problems, make a statement in the remarks section. Always inform operators that follow you on the next shift of any unusual conditions.

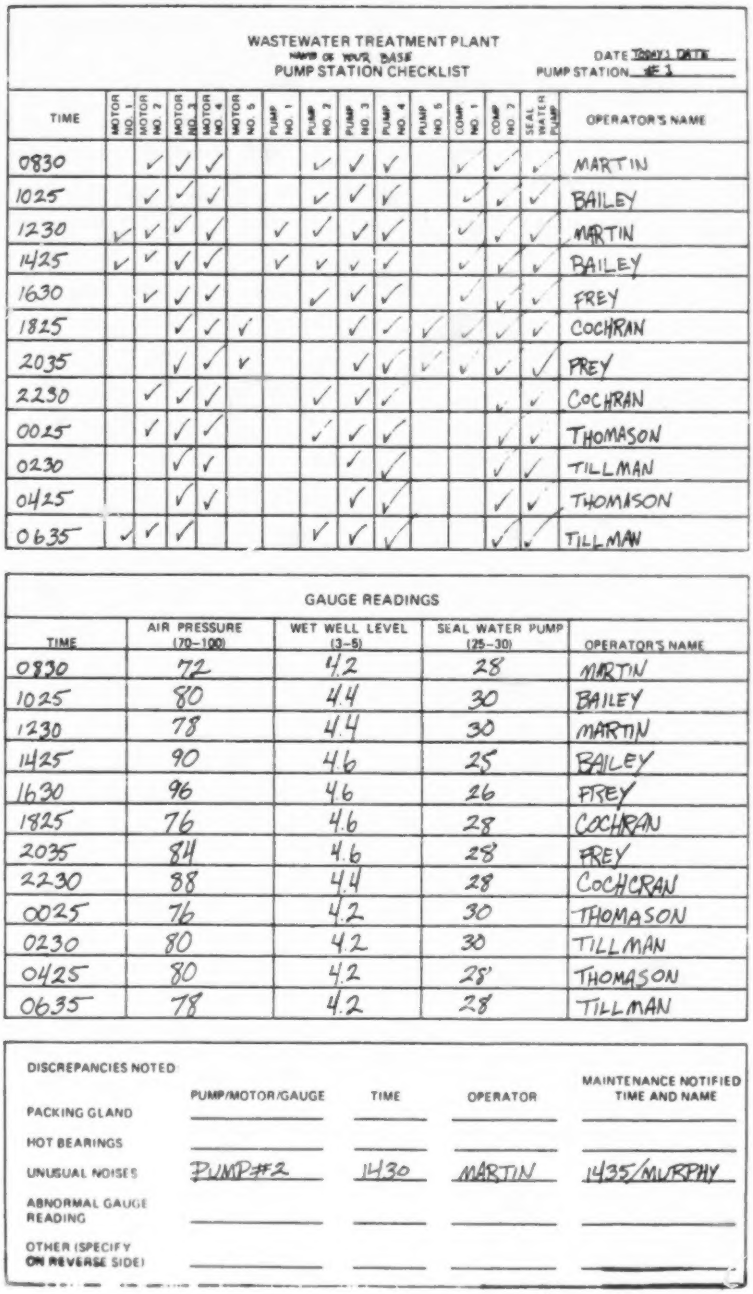
In locating the wastewater lift stations on your base, you will need to have a base map to show you building locations such as the street and building numbers. You need the base maps to set up a route in which to make your lift station run. Set your lift-station run-up for the shortest driving possible. You will save fuel and repair on your vehicle.

A complete set of maps and plans of the wastewater system and treatment plant will be filed at the plant or in the civil engineer's office. These maps shall show the following details: manhole locations with reference points; distance between manholes and building sizes.

Both general and detailed maps of the wastewater distribution system are required. The map should show the following items:

1. The general map shall show the overall system in bold lines, with the width of the lines in proportion to the size of the pipe system. The map will include but will not be limited to pipe sizes, force mains, and direction-of-flow arrows. (See Figure 11-2).

848



WASTEWATER TREATMENT PLANT
NAME OF YOUR BASE
PUMP STATION CHECKLIST

DATE TODAY'S DATE
PUMP STATION #1

TIME	MOTOR NO. 1	MOTOR NO. 2	MOTOR NO. 3	MOTOR NO. 4	MOTOR NO. 5	PUMP NO. 1	PUMP NO. 2	PUMP NO. 3	PUMP NO. 4	PUMP NO. 5	COMP NO. 1	COMP NO. 2	SEAL WATER PUMP	OPERATOR'S NAME
0830		✓	✓	✓			✓	✓	✓		✓	✓	✓	MARTIN
1025		✓	✓	✓			✓	✓	✓		✓	✓	✓	BAILEY
1230	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	MARTIN
1425	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	BAILEY
1630		✓	✓	✓			✓	✓	✓		✓	✓	✓	FREY
1825			✓	✓	✓			✓	✓	✓	✓	✓	✓	COCHRAN
2035			✓	✓	✓			✓	✓	✓	✓	✓	✓	FREY
2230		✓	✓	✓			✓	✓	✓			✓	✓	COCHRAN
0025		✓	✓	✓			✓	✓	✓			✓	✓	THOMASON
0230			✓	✓				✓	✓			✓	✓	TILLMAN
0425			✓	✓				✓	✓			✓	✓	THOMASON
0635	✓	✓	✓				✓	✓	✓			✓	✓	TILLMAN

GAUGE READINGS

TIME	AIR PRESSURE (70–100)	WET WELL LEVEL (3–5)	SEAL WATER PUMP (25–30)	OPERATOR'S NAME
0830	72	4.2	28	MARTIN
1025	80	4.4	30	BAILEY
1230	78	4.4	30	MARTIN
1425	90	4.6	25	BAILEY
1630	96	4.6	26	FREY
1825	76	4.6	28	COCHRAN
2035	84	4.6	28	FREY
2230	88	4.4	28	COCHRAN
0025	76	4.2	30	THOMASON
0230	80	4.2	30	TILLMAN
0425	80	4.2	28	THOMASON
0635	78	4.2	28	TILLMAN

DISCREPANCIES NOTED:

	PUMP/MOTOR/GAUGE	TIME	OPERATOR	MAINTENANCE NOTIFIED TIME AND NAME
PACKING GLAND				
HOT BEARINGS				
UNUSUAL NOISES	PUMP#2	1430	MARTIN	1435/MURPHY
ABNORMAL GAUGE READING				
OTHER (SPECIFY ON REVERSE SIDE)				

Example of Lift Station Checklist

Figure 11-1.

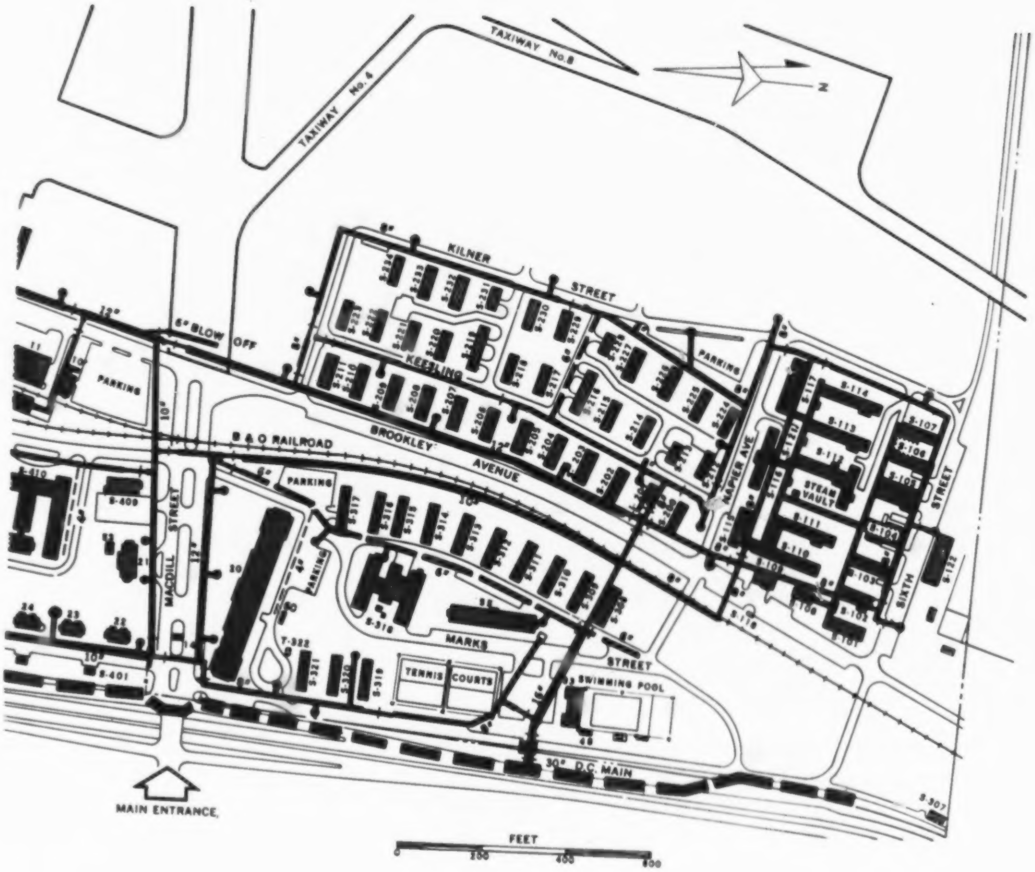

TAXIWAY No.8
TAXIWAY No.4
N
KILNER STREET
KEESLING
PARKING
6" BLOW OFF
12"
10"
B & O RAILROAD
BROOKLEY AVENUE
NAPIER AVE
STEAM VAULT
SIXTH STREET
MACDILL STREET
MARKS STREET
TENNIS COURTS
SWIMMING POOL
30" D.C. MAIN
MAIN ENTRANCE
S-401
S-409
S-410
S-307
FEET
0
200
400
600

Figure 11-2. Part of General Utility Map

2. Detailed utilities maps shall be provided and copies kept available for use by field crews. These maps shall show, but not be limited to, the following details: manhole locations - with reference points; manhole invert and cover elevation; distance between manholes; sewer material, sizes and grades; location of forced main air reliefs and drain sumps. Any modification or addition to the system is noted by making the required changes on the maps. In this manner, the maps are kept up to date.

The best scale for the map is one inch equals 50 feet; but, a scale of one inch equals 100 feet may be used. At a congested intersection, inserts of a larger scale may be needed to show all data clearly.

Because of the large scale, utility maps are usually drawn in several sections; however, the utility map for a small system can be drawn on one sheet. If the installation utility systems are too complex to permit a clear consolidated drawing, then an overlay map can be prepared for each utility system. A general installation map may be used as a base. Relative locations of all systems can then be determined by placing one overlay directly over another.

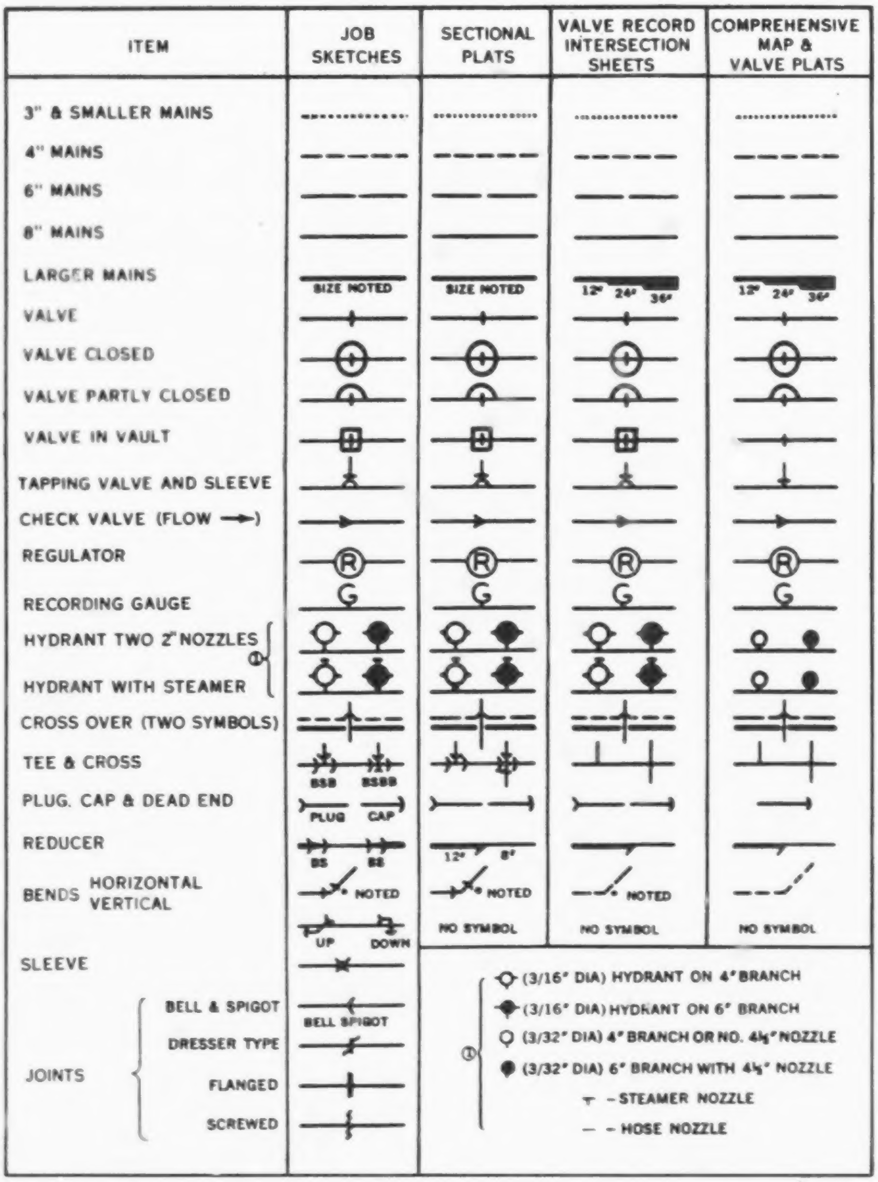
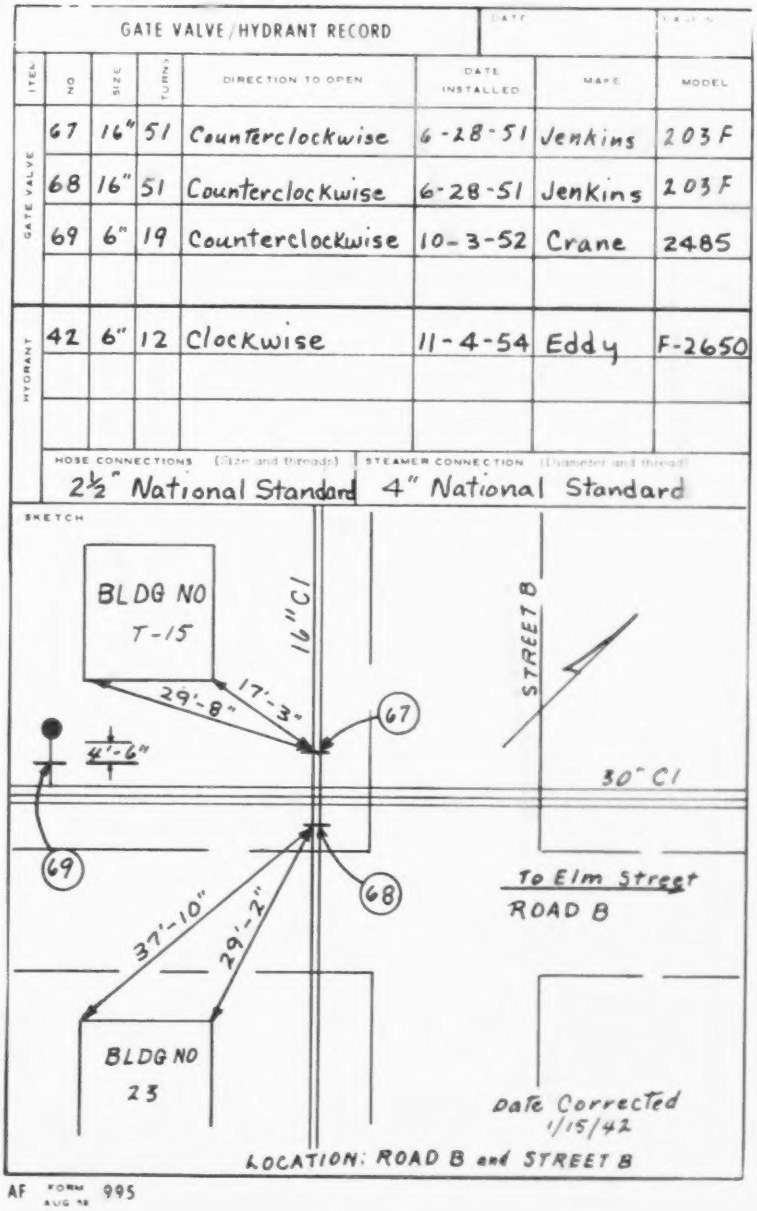

ITEM
JOB SKETCHES
SECTIONAL PLATS
VALVE RECORD INTERSECTION SHEETS
COMPREHENSIVE MAP & VALVE PLATS
3" & SMALLER MAINS
4" MAINS
6" MAINS
8" MAINS
LARGER MAINS
SIZE NOTED
12" 24" 36"
VALVE
VALVE CLOSED
VALVE PARTLY CLOSED
VALVE IN VAULT
TAPPING VALVE AND SLEEVE
CHECK VALVE (FLOW →)
REGULATOR
R
RECORDING GAUGE
G
HYDRANT TWO 2" NOZZLES
HYDRANT WITH STEAMER
①
CROSS OVER (TWO SYMBOLS)
TEE & CROSS
BSB
BSBB
PLUG, CAP & DEAD END
PLUG
CAP
REDUCER
BS
BB
12" 8"
BENDS HORIZONTAL VERTICAL
NOTED
UP
DOWN
NO SYMBOL
SLEEVE
JOINTS
BELL & SPIGOT
BELL SPIGOT
DRESSER TYPE
FLANGED
SCREWED
① (3/16" DIA) HYDRANT ON 4" BRANCH
(3/16" DIA) HYDRANT ON 6" BRANCH
(3/32" DIA) 4" BRANCH OR NO. 4½" NOZZLE
(3/32" DIA) 6" BRANCH WITH 4½" NOZZLE
- STEAMER NOZZLE
- HOSE NOZZLE

Figure 11-3. Universal Symbols for Distribution System Records

SYMBOLS. The symbols shown in Figure 11-3 have been universally adopted to insure uniform, easily interpreted distribution maps. Personnel engaged in preparing distribution maps must follow these symbols exactly.



GATE VALVE/HYDRANT RECORD

DATE

PAGE NO

ITEM	NO	SIZE	TURNS	DIRECTION TO OPEN	DATE INSTALLED	MAKE	MODEL
GATE VALVE	67	16"	51	Counterclockwise	6-28-51	Jenkins	203F
	68	16"	51	Counterclockwise	6-28-51	Jenkins	203F
	69	6"	19	Counterclockwise	10-3-52	Crane	2485
HYDRANT	42	6"	12	Clockwise	11-4-54	Eddy	F-2650

HOSE CONNECTIONS (Size and threads): 2½" National Standard

STEAMER CONNECTION (Diameter and thread): 4" National Standard

SKETCH

Date Corrected 1/15/42

LOCATION: ROAD B and STREET B

AF FORM AUG 58 995

Figure 11-4. AF Form 995, Gate Valve/Hydrant Record

AF Form 995, Gate Valve/Hydrant Record, contains enough detailed information about each valve in the system so the valves can be found and operated quickly at any time. An AF Form 995 is prepared for each valve and hydrant. Enough copies are made of each AF Form 995 to provide a full set of gate valve hydrant records for all distribution system personnel. The sheets are bound into a folder with an index of valve numbers with corresponding sheets or page numbers. A sample gate valve hydrant record is shown in Figure 11-4.

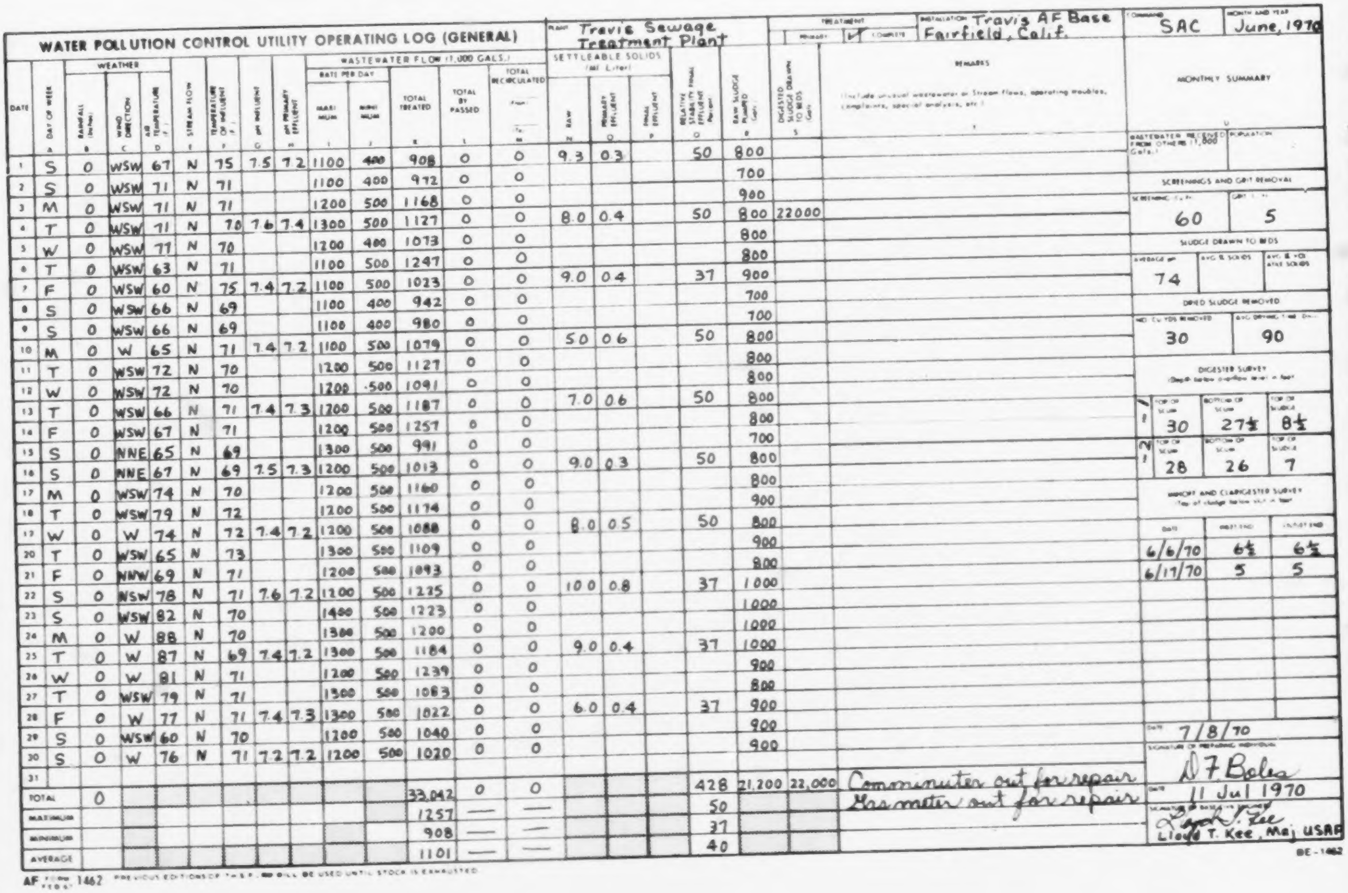
A schematic diagram for each pumping station should show all major piping and control valves in bold lines; indicate source of supply, direction of flow, and point of discharge of piping, purpose, and identifying number of each valve. The diagram should be mounted on the pumping station wall for guidance of operators, and, in emergencies, for personnel not familiar with the layout.

Maintenance Records

It is important to keep good maintenance records. Maintenance records can help you set up a preventive maintenance plan. By following a regular maintenance schedule many equipment malfunctions can be avoided. If equipment does malfunction and you have a record of where to get replacement parts or instructions on how to correct the problem it can usually be corrected faster.

WASTEWATER LOGS. A practical, efficient system of reports and logs is necessary for good operation and maintenance, but such records must be kept accurately and regularly to be of maximum value. Accumulated records are the best means of evaluating methods and processes and indicating effects of changes in population, seasons, and operating procedures. Local records are also valuable aids when designing plant extensions. Figure 11-5 shows AF Form 1462, the Water Pollution Control Utility Operating Log "General," which is used at wastewater treatment plants. Figure 11-6 illustrates AF Form 1463, Water Pollution Control Plant Operating Log "Supplementary," which is required at installations with secondary wastewater treatment or large primary treatment plants with separate sludge digestion where detailed analysis are justified. AF Form 1463 is for use as a supplement to AF Form 1462 at those installations where routine laboratory analysis of solids, biochemical oxygen demand, and dissolved oxygen are required. It is prepared in duplicate for each plant and posted daily by the person in charge of the plant. At the end of the month, it is reviewed by the Base Civil Engineer and the carbon and second copy is forwarded to the Major Air Command. Copies are not forwarded to Headquarters USAF.

DAILY LOGS. Logs are posted at the treatment plant and daily recordings are put on them by the operator. The readings are chlorine residual, settleable solids; dissolved oxygen test; pH of wastewater. You can put on the wastewater log changes in valves being opened or closed on your shift. You can also put on this daily log the temperature of the heat exchanger, boiler water, the temperature of the sludge being put in the digester. You have a remarks section where you enter any unusual conditions of the plant on your shift. The daily logs are changed every day on the morning shift at 8 o'clock. They are kept on file in the wastewater plant office for two years. (See Figures 11-7 and 11-8)



WATER POLLUTION CONTROL UTILITY OPERATING LOG (GENERAL)

PLANT: Travis Sewage Treatment Plant

TREATMENT: ☐ PRIMARY ☑ COMPLETE

INSTALLATION: Travis AF Base Fairfield, Calif.

COMMAND: SAC

MONTH AND YEAR: June, 1970

DATE	DAY OF WEEK A	WEATHER: RAINFALL (Inches) B	WEATHER: WIND DIRECTION C	WEATHER: AIR TEMPERATURE (°F) D	STREAM FLOW E	TEMPERATURE OF INFLUENT (°F) F	pH INFLUENT G	pH PRIMARY EFFLUENT H	WASTEWATER FLOW (1,000 GALS.): RATE PER DAY: MAXIMUM I	RATE PER DAY: MINIMUM J	TOTAL TREATED K	TOTAL BY PASSED L	TOTAL RECIRCULATED M	SETTLEABLE SOLIDS (ml Liter): RAW N	PRIMARY EFFLUENT O	FINAL EFFLUENT P	RELATIVE STABILITY FINAL EFFLUENT Percent Q	RAW SLUDGE PUMPED (Gals) R	DIGESTED SLUDGE DRAWN TO BEDS (Gals) S	REMARKS (Include unusual wastewater or Stream flows, operating troubles, complaints, special analysis, etc.) T
1	S	0	WSW	67	N	75	7.5	7.2	1100	400	908	0	0	9.3	0.3		50	800		
2	S	0	WSW	71	N	71			1100	400	972	0	0					700		
3	M	0	WSW	71	N	71			1200	500	1168	0	0					900		
4	T	0	WSW	71	N	70	7.6	7.4	1300	500	1127	0	0	8.0	0.4		50	800	22000	
5	W	0	WSW	77	N	70			1200	400	1073	0	0					800		
6	T	0	WSW	63	N	71			1100	500	1247	0	0					800		
7	F	0	WSW	60	N	75	7.4	7.2	1100	500	1023	0	0	9.0	0.4		37	900		
8	S	0	WSW	66	N	69			1100	400	942	0	0					700		
9	S	0	WSW	66	N	69			1100	400	980	0	0					700		
10	M	0	W	65	N	71	7.4	7.2	1100	500	1079	0	0	5.0	0.6		50	800		
11	T	0	WSW	72	N	70			1200	500	1127	0	0					800		
12	W	0	WSW	72	N	70			1200	500	1091	0	0					800		
13	T	0	WSW	66	N	71	7.4	7.3	1200	500	1187	0	0	7.0	0.6		50	800		
14	F	0	WSW	67	N	71			1200	500	1257	0	0					800		
15	S	0	NNE	65	N	69			1300	500	991	0	0					700		
16	S	0	NNE	67	N	69	7.5	7.3	1200	500	1013	0	0	9.0	0.3		50	800		
17	M	0	WSW	74	N	70			1200	500	1160	0	0					800		
18	T	0	WSW	79	N	72			1200	500	1174	0	0					900		
19	W	0	W	74	N	72	7.4	7.2	1200	500	1088	0	0	8.0	0.5		50	800		
20	T	0	WSW	65	N	73			1300	500	1109	0	0					900		
21	F	0	NNW	69	N	71			1200	500	1093	0	0					800		
22	S	0	WSW	78	N	71	7.6	7.2	1200	500	1235	0	0	10.0	0.8		37	1000		
23	S	0	WSW	82	N	70			1400	500	1223	0	0					1000		
24	M	0	W	88	N	70			1300	500	1200	0	0					1000		
25	T	0	W	87	N	69	7.4	7.2	1300	500	1184	0	0	9.0	0.4		37	1000		
26	W	0	W	81	N	71			1200	500	1239	0	0					900		
27	T	0	WSW	79	N	71			1300	500	1063	0	0					800		
28	F	0	W	77	N	71	7.4	7.3	1300	500	1022	0	0	6.0	0.4		37	900		
29	S	0	WSW	60	N	70			1200	500	1040	0	0					900		
30	S	0	W	76	N	71	7.2	7.2	1200	500	1020	0	0					900		
31																				
TOTAL		0									33,042	0	0				428	21,200	22,000	Comminuter out for repair
MAXIMUM											1257	—	—				50			Gas meter out for repair
MINIMUM											908	—	—				37			
AVERAGE											1101	—	—				40			

MONTHLY SUMMARY U

WASTEWATER RECEIVED FROM OTHERS (1,000 Gals.):

POPULATION:

SCREENINGS AND GRIT REMOVAL

SCREENINGS	GRIT
60	5

SLUDGE DRAWN TO BEDS

AVERAGE pH	AVG. % SOLIDS	AVG. % VOLATILE SOLIDS
74		

DRIED SLUDGE REMOVED

NO. CU. YDS REMOVED	AVG. DRYING TIME (Days)
30	90

DIGESTER SURVEY (Depth below overflow level in feet)

TOP OF SCUM	BOTTOM OF SCUM	TOP OF SLUDGE
30	27½	8½
28	26	7

IMHOFF AND CLARIGESTER SURVEY (Top of sludge below slot in feet)

DATE	INLET END	OUTLET END
6/6/70	6½	6½
6/17/70	5	5

DATE: 7/8/70

SIGNATURE OF PREPARING INDIVIDUAL: D F Boles

DATE: 11 Jul 1970

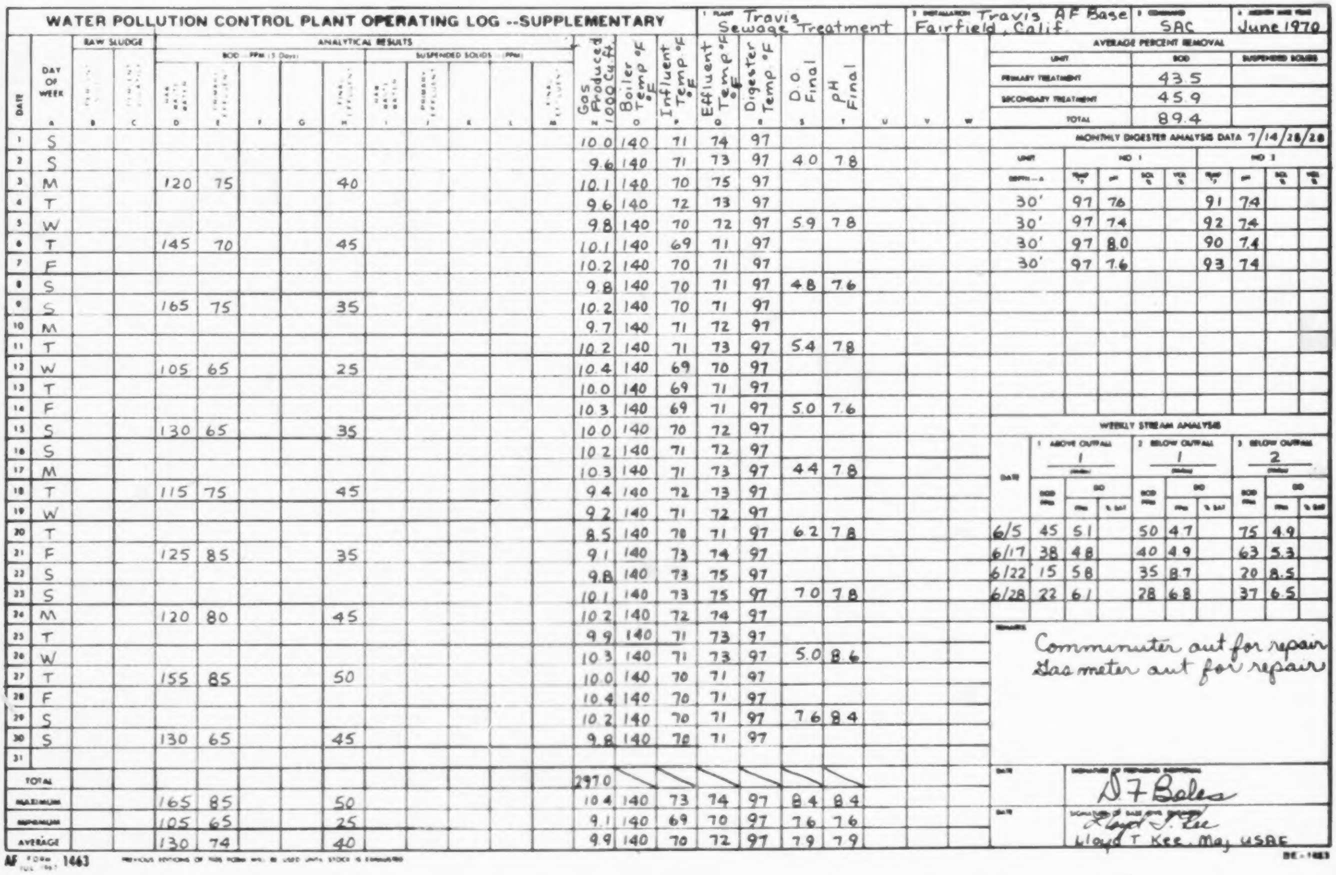
SIGNATURE OF BASE CIVIL ENGINEER: Lloyd T. Kee

Lloyd T. Kee, Maj USAF

BE-1462

AF FORM 1462 FEB 67 PREVIOUS EDITIONS OF THIS FORM WILL BE USED UNTIL STOCK IS EXHAUSTED.

Figure 11-5. AF Form 1462, Water Pollution Control Utility Operating Log (General)



WATER POLLUTION CONTROL PLANT OPERATING LOG --SUPPLEMENTARY

1 PLANT Travis Sewage Treatment

2 INSTALLATION Travis AF Base Fairfield, Calif.

3 COMMAND SAC

4 MONTH AND YEAR June 1970

DATE	DAY OF WEEK A	RAW SLUDGE B	RAW SLUDGE C	BOD – PPM (5 Days) D	E PRIMARY EFFLUENT	F	G	H FINAL EFFLUENT	SUSPENDED SOLIDS – (PPM) I	J PRIMARY EFFLUENT	K	L	M FINAL EFFLUENT	N Gas Produced 1000 Cu Ft	O Boiler Temp °F	P Influent Temp °F	Q Effluent Temp °F	R Digester Temp °F	S D.O. Final	T pH Final	U	V	W
1	S													10.0	140	71	74	97					
2	S													9.6	140	71	73	97	4.0	7.8			
3	M			120	75			40						10.1	140	70	75	97					
4	T													9.6	140	72	73	97					
5	W													9.8	140	70	72	97	5.9	7.8			
6	T			145	70			45						10.1	140	69	71	97					
7	F													10.2	140	70	71	97					
8	S													9.8	140	70	71	97	4.8	7.6			
9	S			165	75			35						10.2	140	70	71	97					
10	M													9.7	140	71	72	97					
11	T													10.2	140	71	73	97	5.4	7.8			
12	W			105	65			25						10.4	140	69	70	97					
13	T													10.0	140	69	71	97					
14	F													10.3	140	69	71	97	5.0	7.6			
15	S			130	65			35						10.0	140	70	72	97					
16	S													10.2	140	71	72	97					
17	M													10.3	140	71	73	97	4.4	7.8			
18	T			115	75			45						9.4	140	72	73	97					
19	W													9.2	140	71	72	97					
20	T													8.5	140	70	71	97	6.2	7.8			
21	F			125	85			35						9.1	140	73	74	97					
22	S													9.8	140	73	75	97					
23	S													10.1	140	73	75	97	7.0	7.8			
24	M			120	80			45						10.2	140	72	74	97					
25	T													9.9	140	71	73	97					
26	W													10.3	140	71	73	97	5.0	8.6			
27	T			155	85			50						10.0	140	70	71	97					
28	F													10.4	140	70	71	97					
29	S													10.2	140	70	71	97	7.6	8.4			
30	S			130	65			45						9.8	140	70	71	97					
31																							
TOTAL														297.0									
MAXIMUM				165	85			50						10.4	140	73	74	97	8.4	8.4			
MINIMUM				105	65			25						9.1	140	69	70	97	7.6	7.6			
AVERAGE				130	74			40						9.9	140	70	72	97	7.9	7.9			

AVERAGE PERCENT REMOVAL

UNIT	BOD	SUSPENDED SOLIDS
PRIMARY TREATMENT	43.5	
SECONDARY TREATMENT	45.9	
TOTAL	89.4	

MONTHLY DIGESTER ANALYSIS DATA 7/14/28/28

UNIT	NO 1				NO 2			
DEPTH	TEMP °F	pH	SOL %	VOL %	TEMP °F	pH	SOL %	VOL %
30′	97	7.6			91	7.4		
30′	97	7.4			92	7.4		
30′	97	8.0			90	7.4		
30′	97	7.6			93	7.4		

WEEKLY STREAM ANALYSIS

DATE	1 ABOVE OUTFALL 1 (miles)			2 BELOW OUTFALL 1 (miles)			3 BELOW OUTFALL 2 (miles)		
	BOD PPM	DO PPM	DO % SAT	BOD PPM	DO PPM	DO % SAT	BOD PPM	DO PPM	DO % SAT
6/5	45	5.1		50	4.7		75	4.9	
6/17	38	4.8		40	4.9		63	5.3	
6/22	15	5.8		35	8.7		20	8.5	
6/28	22	6.1		28	6.8		37	6.5	

REMARKS

Communuter out for repair
Gas meter out for repair

DATE

SIGNATURE D F Boles

DATE

SIGNATURE Lloyd T. Kee
Lloyd T Kee, Maj, USAF

AF FORM 1463 JUL 1967 PREVIOUS EDITIONS OF THIS FORM WILL BE USED UNTIL STOCK IS EXHAUSTED

Figure 11-6. AF Form 1463. Water Pollution Control Plant

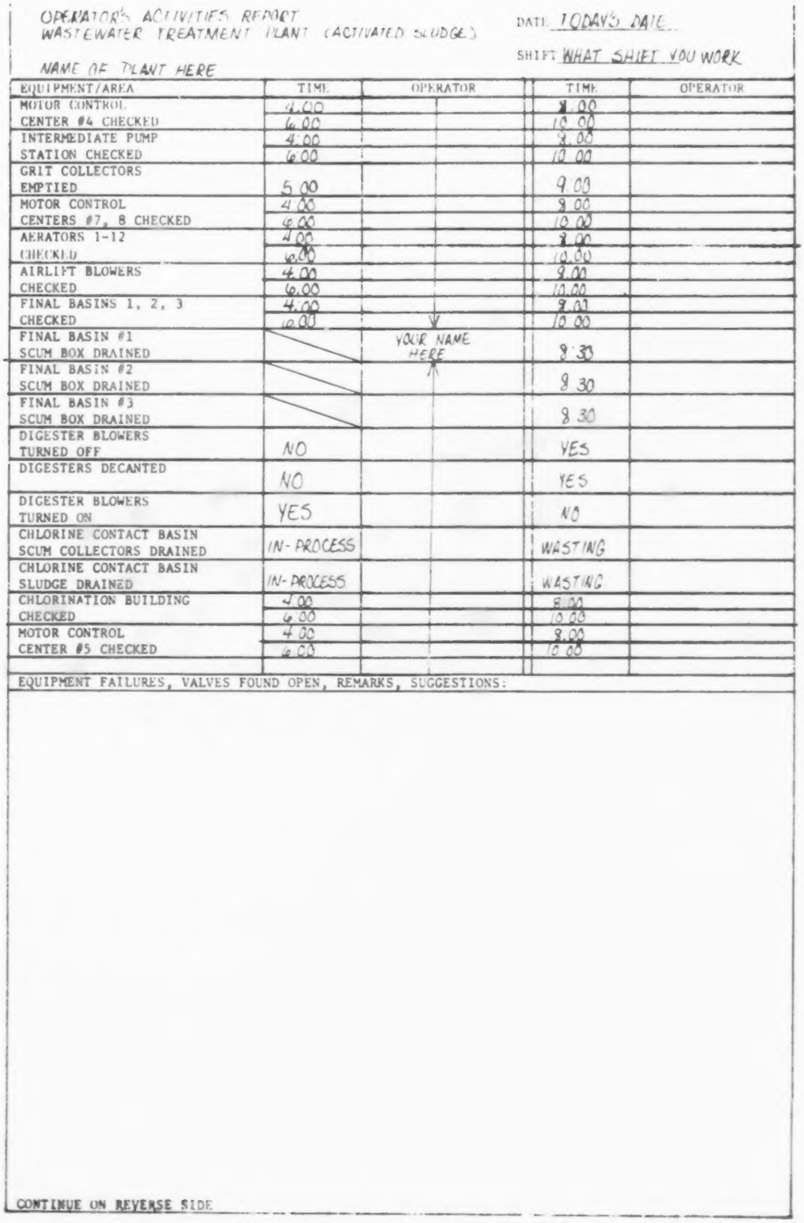
NAME OF WASTEWATER PLANT DAILY LOG DATE change date everyday

	WIND DIRECTION	RAIN FALL IN.	ATSM. TEMP.	RAW TEMP.	GRIT REMOVED CUFT	RAGS GROUND CUFT	SETTLEABLE SOLIDS				SLUDGE IN	DIGESTER HEATER				GAUGE BOARD	LBS. CL_2 USED				REMARKS
							RAW	P.E.	F.E.	CL_2 RESIDUAL		SLUDGE OUT	HEATER WATER	WATER BATH	DIGESTER MONOMETER						
8:00 AM	S	O	52	70		05	1.0	T	T	1.0	93	95	104	100	44	32	—				
10:00 AM	SW	O	54	72	1.0	05	25	T	T	1.0	94	95	106	100	6.0	32	—				
12 NOON	S	O	58	72		0.5	10.0	T	T	1.0	93	95	104	100	5.2	32	—				
2:00 PM	W	O	60	72	—	05	8.0	T	T	1.0	93	95	104	100	50	38	—				
4:00 PM	W	0	62	74	05	0.5	2.0	T	T	1.0	94	95	104	100	72	40	—				
6:00 PM	SW	0	66	74	—	05	10.0	T	T	1.0	94	95	104	100	4.0	3.8	—				
8:00 PM	S	0	70	72	—	0.5	2.5	T	T	1.0	93	95	102	100	3.2	3.5	—				
10:00 PM	S	0	72	74	—	0.5	1.5	T	T	1.0	93	95	104	100	6.0	33					
12:00 AM	SW	0	72	73	—	05	1.0	T	T	1.0	93	95	102	100	6.8	33					
2:00 AM	SW	0	72	73	1.0	0.5	1.0	T	T	1.0	93	95	102	100	7.2	33					
4:00 AM	SE	0	80	73	—	0.5	0.5	T	T	1.0	93	95	102	100	7.8	33					
6:00 AM	S	0	88	76	—	0.5	1.0	T	T	1.0											
TOTAL	S	0				6.0															
AVERAGE	S	0				0.5															

RECORD REMARKS ON REVERSE SIDE	GRIT REMOVED	LINK BELT CLEANED	PRIMARY BASINS 1, 2 CHECKED	RAW SLUDGE PUMPS 1, 2, 3 CHECKED	SCUM PUMPED	SUMP/SEAL WATER PUMPS CHECKED (RAW SLUDGE BLDG.)	TRICKLING FILTERS 1, 2 CLEANED	FINAL BASIN CHECKED	RECIRCULATION PUMPS 1, 2 CHECKED	SLUDGE CIRCULATING PUMPS 1, 2 CHECKED	SUMP/SEAL WATER PUMPS CHECKED (DIGESTOR BLDG.)	PRIMARY AND TRANSFER SLUDGE BOXES CHECKED	GASLINE CONDENSATION TRAPS DRAINED (MAIN FL)	GASLINE CONDENSATION TRAPS DRAINED (BASEMENT)	REMARKS
8:00 AM	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	
10:00 AM		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	
12 NOON		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	
2:00 PM		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
4:00 PM	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	
6:00 PM		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	
8:00 PM		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
10:00 PM		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	
12:00 AM	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	
2:00 AM		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
4:00 AM		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	
6:00 AM		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	

1 OPERATOR'S NAME 2 OPERATOR'S NAME 3 OPERATOR'S NAME

Figure 11-7.



OPERATOR'S ACTIVITIES REPORT
WASTEWATER TREATMENT PLANT (ACTIVATED SLUDGE)

NAME OF PLANT HERE

DATE TODAY'S DATE

SHIFT WHAT SHIFT YOU WORK

EQUIPMENT/AREA	TIME	OPERATOR	TIME	OPERATOR
MOTOR CONTROL CENTER #4 CHECKED	4.00 6.00		8.00 10.00	
INTERMEDIATE PUMP STATION CHECKED	4:00 6:00		8.00 10.00	
GRIT COLLECTORS EMPTIED	5.00		9:00	
MOTOR CONTROL CENTERS #7, 8 CHECKED	4:00 6.00		8:00 10.00	
AERATORS 1-12 CHECKED	4.00 6.00		8.00 10.00	
AIRLIFT BLOWERS CHECKED	4.00 6.00		9.00 10.00	
FINAL BASINS 1, 2, 3 CHECKED	4.00 6.00		8.00 10.00	
FINAL BASIN #1 SCUM BOX DRAINED		YOUR NAME HERE	8:30	
FINAL BASIN #2 SCUM BOX DRAINED			8.30	
FINAL BASIN #3 SCUM BOX DRAINED			8.30	
DIGESTER BLOWERS TURNED OFF	NO		YES	
DIGESTERS DECANTED	NO		YES	
DIGESTER BLOWERS TURNED ON	YES		NO	
CHLORINE CONTACT BASIN SCUM COLLECTORS DRAINED	IN-PROCESS		WASTING	
CHLORINE CONTACT BASIN SLUDGE DRAINED	IN-PROCESS		WASTING	
CHLORINATION BUILDING CHECKED	4.00 6.00		8.00 10.00	
MOTOR CONTROL CENTER #5 CHECKED	4.00 6.00		8.00 10.00	

EQUIPMENT FAILURES, VALVES FOUND OPEN, REMARKS, SUGGESTIONS:

CONTINUE ON REVERSE SIDE

Figure 11-8.

EXERCISE IV-11-11a

PART 1

INSTRUCTIONS

Using SW J3ABR56631 000-IV-11, complete the following statements.

1. Why do you keep records on equipment and facilities? ______

2. How often are lift-stations checked? ______

3. What help will a base map give you on a lift station run? ______

4. Why are maintenance records important? ______

5. What is Air Force Form 995? ______

6. A schematic diagram for each pumping station should show what? ______

7. Why are wastewater logs necessary? ______

8. What is AF Form 1462? ______

9. What is AF Form 1463? ______

10. How often are AF Forms 1462 and 1643 posted? ______

11. What are three readings put on the daily log sheet?
    a. ______
    b. ______
    c. ______

PART 2

INSTRUCTIONS

Using Air Force Form 1462 and the information below, complete filling in of the form.

PART A

1. On June 28, rainfall 0, wind direction WSW, air temperature 80, temperature of influent 71, pH influent 7.5, pH effluent 7.3, rate per day max. 1200, min. 500, total treated 1012, bypassed 0. Recirculated 0, settleable solids raw 9.5, primary 0.6, relative stability final effluent 39 and raw sludge pumped 700.

2. On June 29, rainfall 0, wind direction W, air temperature 85, temperature of influent 73, rate per day max. 1300, min. 500, total treated 1098, bypassed 0, recirculated 0, and raw sludge pumped 900.

3. On June 30, rainfall 0, wind direction W, air temperature 82, temperature of influent 72, rate per day max 1400, min. 500, total treated 1125, bypassed 0, recirculated 0, raw sludge pumped 1,000.

PART B

INSTRUCTIONS

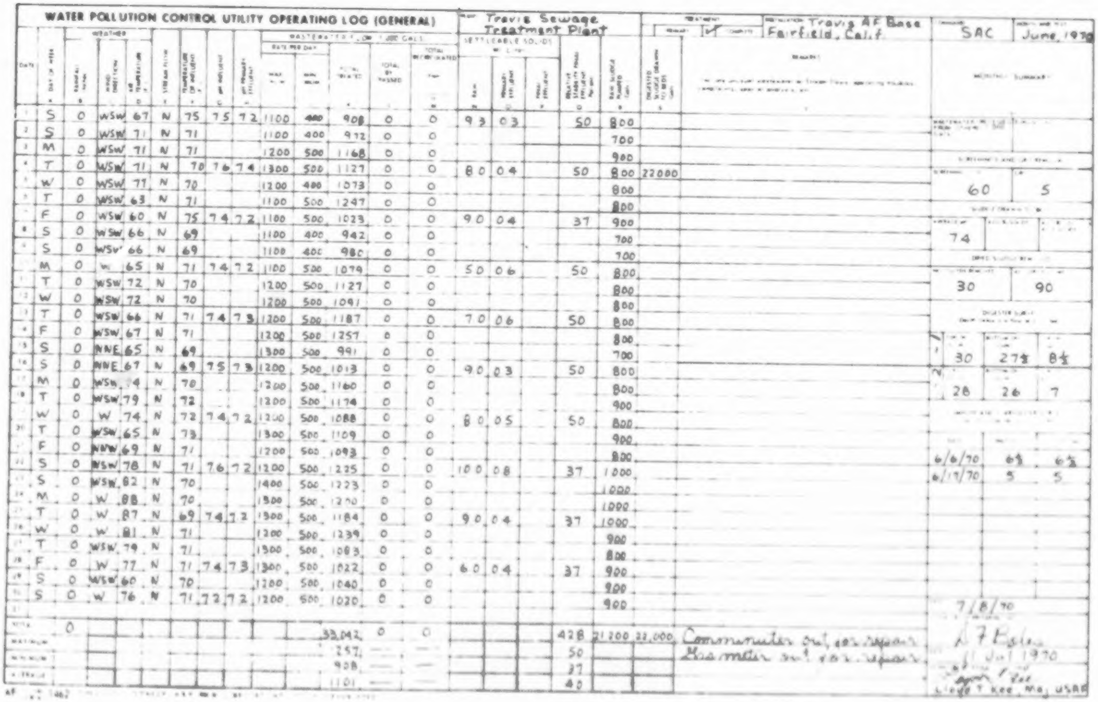
Using Air Force Form 1463 and the information below, complete filling in of the form.

1. On June 27 the BOD on the raw wastewater was 155; BOD on the primary effluent was 85; BOD on the final effluent was 50; gas produced was 10,000 cubic feet; boiler temperature was 140°F; influent temperature was 70°F; effluent temperature was 71°F; the digester temperature was 97°F.

2. On June 28 the gas produced was 10,400 cubic feet; the boiler temperature was 140°F, influent wastewater temperature was 70°F; the effluent temperature was 71°F; the temperature of the digester was 97°F; D.O. of the final effluent was 7.6, pH of the final effluent is 8.4.

3. On June 29 the gas produced was 10,200 cubic feet; the boiler temperature was 140°F; the influent temperature was 70°F; the effluent temperature was 71°F; the temperature of the digester was 97°F; the D.O. final was 7.6 and the pH of the final was 8.4.

4. On June 30 the raw wastewater BOD was 130; the primary effluent BOD was 65; the BOD of the final effluent was 45; the gas produced was 9,800 cubic feet; the boiler temperatrure was 140°F; the influent temperature was 70°F; the effluent temperature as 71°F; the digester temperature was 97°F.



WATER POLLUTION CONTROL UTILITY OPERATING LOG (GENERAL)

Plant: Travis Sewage Treatment Plant

Treatment: Primary ☐ Complete ☑

Installation: Travis AF Base Fairfield, Calif.

Command: SAC

Month and year: June, 1970

Date	Day of week	Weather			Stream flow				Wastewater flow 1,000 gals					Settleable solids						Remarks
									Rate per day		Total treated	Total by passed	Total recirculated							
1	S	0	WSW	67	N	75	75	72	1100	400	908	0	0	93	03		50	800		
2	S	0	WSW	71	N	71			1100	400	912	0	0					700		
3	M	0	WSW	71	N	71			1200	500	1168	0	0					900		
4	T	0	WSW	71	N	70	76	74	1300	500	1127	0	0	80	04		50	800	22000	
5	W	0	WSW	77	N	70			1200	400	1073	0	0					800		
6	T	0	WSW	63	N	71			1100	500	1247	0	0					800		
7	F	0	WSW	60	N	75	74	72	1100	500	1023	0	0	90	04		37	900		
8	S	0	WSW	66	N	69			1100	400	942	0	0					700		
9	S	0	WSW	66	N	69			1100	400	980	0	0					700		
10	M	0	W	65	N	71	74	72	1100	500	1079	0	0	50	06		50	800		
11	T	0	WSW	72	N	70			1200	500	1127	0	0					800		
12	W	0	WSW	72	N	70			1200	500	1091	0	0					800		
13	T	0	WSW	66	N	71	74	73	1200	500	1187	0	0	70	06		50	800		
14	F	0	WSW	67	N	71			1200	500	1257	0	0					800		
15	S	0	NNE	65	N	69			1300	500	991	0	0					700		
16	S	0	NNE	67	N	69	75	73	1200	500	1013	0	0	90	03		50	800		
17	M	0	WSW	74	N	70			1200	500	1160	0	0					800		
18	T	0	WSW	79	N	72			1200	500	1174	0	0					900		
19	W	0	W	74	N	72	74	72	1200	500	1088	0	0	80	05		50	800		
20	T	0	WSW	65	N	73			1300	500	1109	0	0					900		
21	F	0	NNW	69	N	71			1200	500	1093	0	0					800		
22	S	0	WSW	78	N	71	76	72	1200	500	1225	0	0	100	08		37	1000		
23	S	0	WSW	82	N	70			1400	500	1223	0	0					1000		
24	M	0	W	88	N	70			1300	500	1270	0	0					1000		
25	T	0	W	87	N	69	74	72	1300	500	1184	0	0	90	04		37	1000		
26	W	0	W	81	N	71			1200	500	1239	0	0					900		
27	T	0	WSW	79	N	71			1300	500	1083	0	0					800		
28	F	0	W	77	N	71	74	73	1300	500	1022	0	0	60	04		37	900		
29	S	0	WSW	60	N	70			1200	500	1040	0	0					900		
30	S	0	W	76	N	71	72	72	1200	500	1020	0	0					900		
31																				
Total		0									33,042	0	0				428	21200	22,000	Comminuter out for repair
Maximum											1257	—	—				50			Gas meter out for repair
Minimum											908	—	—				37			
Average											1101	—	—				40			

Monthly Summary

60	5

74		

30	90

1	30	27½	8½
2	28	26	7

6/6/70	6½	6½
6/17/70	5	5

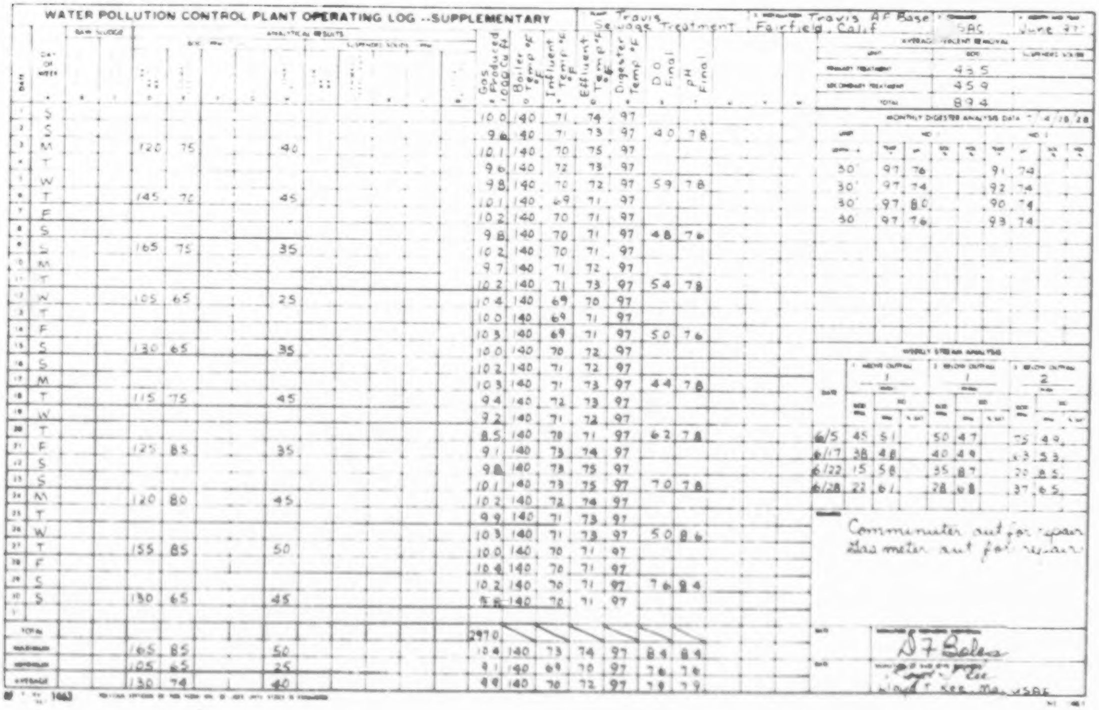
7/8/70

A F Bales

11 Jul 1970

Lloyd T Kee, Maj, USAF

AF Form 1462. Water Pollution Control Utility Operating Log (General)



WATER POLLUTION CONTROL PLANT OPERATING LOG --SUPPLEMENTARY

Travis Sewage Treatment

Travis AF Base Fairfield, Calif

SAC

June 77

Date	Day of Week	Raw Sludge		Analytical Results										Gas Produced 1000 Cu ft	Boiler Temp °F	Influent Temp °F	Effluent Temp °F	Digester Temp °F	D.O. Final	pH Final			
1	S													10.0	140	71	74	97					
2	S													9.6	140	71	73	97	40	78			
3	M			120	75			40						10.1	140	70	75	97					
4	T													9.6	140	72	73	97					
5	W													9.8	140	70	72	97	59	78			
6	T			145	70			45						10.1	140	69	71	97					
7	F													10.2	140	70	71	97					
8	S													9.8	140	70	71	97	48	76			
9	S			165	75			35						10.2	140	70	71	97					
10	M													9.7	140	71	72	97					
11	T													10.2	140	71	73	97	54	78			
12	W			105	65			25						10.4	140	69	70	97					
13	T													10.0	140	69	71	97					
14	F													10.3	140	69	71	97	50	76			
15	S			130	65			35						10.0	140	70	72	97					
16	S													10.2	140	71	72	97					
17	M													10.3	140	71	73	97	44	78			
18	T			115	75			45						9.4	140	72	73	97					
19	W													9.2	140	71	72	97					
20	T													8.5	140	70	71	97	62	78			
21	F			125	85			35						9.1	140	73	74	97					
22	S													9.8	140	73	75	97					
23	S													10.1	140	73	75	97	70	78			
24	M			120	80			45						10.2	140	72	74	97					
25	T													9.9	140	71	73	97					
26	W													10.3	140	71	73	97	50	86			
27	T			155	85			50						10.0	140	70	71	97					
28	F													10.4	140	70	71	97					
29	S													10.2	140	70	71	97	76	84			
30	S			130	65			45						[illegible]	140	70	71	97					
31																							
Total														297.0									
Maximum				165	85			50						10.4	140	73	74	97	84	84			
Minimum				105	65			25						9.1	140	69	70	97	76	76			
Average				130	74			40						9.9	140	70	72	97	79	79			

Average Percent Removal

Unit	BOD	Suspended Solids
Primary Treatment	435	
Secondary Treatment	459	
Total	894	

Monthly Digester Analysis Data 4 18 28

Unit	No. 1				No. 2			
	Temp	pH			Temp	pH		
30'	97	76			91	74		
30'	97	74			92	74		
30'	97	80			90	74		
30	97	76			93	74		

Weekly Stream Analysis

Date	1. Above Outfall 1			2. Below Outfall 1			3. Below Outfall 2		
	BOD	DO	% Sat	BOD	DO	% Sat	BOD	DO	% Sat
6/5	45	51		50	47		75	49	
6/17	38	48		40	49		63	53	
6/22	15	58		35	87		20	65	
6/28	22	61		28	68		37	65	

Comminuter out for repair
Gas meter out for repair

D F Bales

Lloyd T. Lee, Maj, USAF

AF 1463

AF Form 1463. Water Pollution Control utility Operating Log -- Supplementary

PROGRESS CHECK

You should be ready for the progress check. If you feel you need to review some of the previous instruction, do so. The progress check is prepared as a separate publication and controlled by the instructor. You must do the progress check under instructor supervision and complete it prior to leaving for the day.

SUMMARY

Records are a must in wastewater treatment. You must know at all times what changes are taking place in your plant. You must be able to locate all your lift stations and at all times know how they are being kept in good working condition. You need good maps of your distribution system to show you pipe sizes and where force mains are located. Copies are kept on hand for field crews. The gate valve/hydrant record should contain enough detailed information about each valve in the system so the valves can be found and operated quickly at any time.

Wastewater records are an important part of plant operation. You found that AF Forms 1462 and 1463 are monthly operating logs. AF Form 1462 is used at all installations which have a treatment plant with the exception of septic tanks. AF Form 1463 supplements Form 1462 at plants using secondary treatment. Daily logs are changed every day on the morning shift at your wastewater plant.

PROGRESS CHECK
J3ABR56631 000-IV-1 thru 11

Technical Training

Environmental Support Specialist

WASTEWATER TREATMENT AND DISPOSAL

July 1986

3700 TECHNICAL TRAINING WING
3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

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Wastewater Treatment and Disposal

Table of Contents

Progress Checks J3ABR56631 000-IV-1 thru 11

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Supersedes WB J3ABR56631-IV-1 thru 11, dated June 1984.

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3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-1

CHARACTERISTICS OF WASTEWATER

OBJECTIVE

Given information concerning the characteristics and composition of wastewater and a list of incomplete statements and phrases, write the terms or phrases to complete each statement. Fifteen of the twenty statements must be correct.

REFERENCES/EQUIPMENT/MATERIALS

SW J3ABR56631 000-IV-1 thru 11
AFM 91-32

INSTRUCTIONS:

1. This progress check contains 20 items, you must correctly answer 15 in order to receive a satisfactory rating.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS

Fill in the correct term or phrase which will complete the following statements. You may use AFM 91-32 and your study guide for assistance.

1. The NPDES limits that is published by the EPA state the ________________________ ________________________ pollutants discharge limits.

2. The extent of water pollution control depends on the ________________________ ________________________ by regulatory agencies.

3. Composition of most materials in wastewater are expressed in ____________________ ________________________ which tells the ________________________ of the wastewater.

4. The physical characteristics of wastewater are ________________, ________________, ____________________, and ____.

5. Changes in wastewater temperatures will affect the ______________ ______________, __________________ __________________ __________________, and ____________________ ____________________________.

6. The color of wastewater with D.O. present will normally be ______________________.

7. Domestic wastewater will normally have a ____________________________ odor.

8. Most industrial wastes need ____________________________________ prior to being introduced into a collection system.

9. The most common types of solids in wastewater are ______________, ______________, ______________, ______________, ______________, ______________ and ______________.

10. The chemical charcteristics of wastewater that are of special concern to plant operators are __________, ____________ ____________, ____________ ____________, ______________________ ______________________.

11. Bacteria in wastewater that contains D.O. are called ______________ bacteria.

12. Bacteria in wastewater that contains no D.O. are called ______________ bacteria.

13. The nutrients present in domestic wastewater are ____________ and ____________.

14. These nutrients cause __________ ____________ of ______________________ in receiving waterways.

15. Three biological organisms present in wastewater are ____________, ______________ and ______________________.

16. Tests for total coliform and fecal coliform are used to indicate the presence of ________________ ________________.

17. Bacteria that can live with or without the presence of D.O. in wastewater are called ______________________ bacteria.

18. Viruses in wastewater can be removed by ________________, ________________, ______________________, and ______________________.

19. Parasites can generally be removed from wastewater by ______________, __________ ______________________, ______________________ or ______________________.

20. Three sources of wastewater originate from __________, ________________ and ______________________.

3770 Technical Training Group
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-2a

WASTEWATER PLANT SAFETY

OBJECTIVE

Given a list of unsafe conditions and violations, select the safe rule or practice to eliminate the violation. Seven of ten must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS

1. This progress check contains ten items, you must correctly answer seven in order to receive a satisfactory rating.
2. When you have completed the progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Read the unsafe condition or act in Column A and select the correct safety statement from Column B to eliminate the unsafe condition. Items in Column B may be used once, more than once or not at all.

COLUMN A

____ 1. An operator has splashed a chemical in his/her eyes.

____ 2. An operator wants to know how to identify and eliminate unhealthy conditions and to protect property.

____ 3. While working in a lift station, the operator has become dizzy and weak, short of breath.

____ 4. The noise from a standby engine is hurting your ears and giving you a headache.

____ 5. A chlorine cylinder fell on your foot during loading activities. Serious injury has occurred.

____ 6. You recognize that your co-worker is in the state of electrical shock. What is the first action to take.

____ 7. Complaints are brought to your attention from other plant operators concerning which water line contains potable water.

____ 8. The water traps in digester gas collection equipment are inoperative due to freezing.

____ 9. After a new plant has been built, you should insure that all aeration tanks, open pits and wells are equipped with what two safety items.

COLUMN B

a. Safety-toe shoe

b. Read/know OSHA recommendations

c. Use an oxygen feed device

d. Use emergency eye wash

e. Rubber boots

f. Use goggles or face shield

g. Cotton plugs

h. Read/know AFOSH regulations

i. Use emergency shower

j. Wear a filter mask

k. Ear plugs

l. Non-skid shoes

m. Give CPR immediately

___ 10. You observe an operator cleaning the trickling filter unit as the wastewater is flowing through the rotating arms.	n. Guard rails and life preservers
	o. Lights and walkways
	p. Use color coding and signs
	q. Stop the bleeding
	r. Use antifreeze
	s. Use printed arrows
	t. Remove live conductor
	u. Anchor or tie down the distributors

3770 Technical Training Group
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-3a

POLLUTION CONTROL POLICIES AND PROGRAM

OBJECITVE

Given information concerning Environmental Pollution Control Policies and Programs and a list of incomplete statements, write the phrase or term to complete each statement. Seven of ten must be correct.

REFERENCES/EQUIPMENT/MATERIALS

SW J3ABR56631 000-IV-1 thru 11

INSTRUCTIONS:

1. This progress check contains ten items. You must correctly answer seven in order to receive a satisfactory rating.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Using your study guide select the correct phrase or term that will complete the incomplete statements pertaining to pollution policies and controls.

1. Under Executive Order 11752, the President has stipulated that ____________________

____

____

____

2. Permit is not a license to ______________________________.

3. Wastewater pollution controls set a limit on the plant ____________________ to

the ____________________.

4. Three types of records kept for a wastewater treatment plant are ______________,

________________ and ________________ records.

5. Plant reports and lab records must be kept for at least __________ __________.

6. Local agencies are run by the ____________________ of the community.

7. The state has the power to ______________, to ______________ ______________ and

to ________________ the sources of pollution.

8. The ________________issues permits to prevent, reduce and do away with __________

________________________.

9. The ____________________ is required to have nationwide wastewater effluent

limitations.

10. The purpose of having wastewater treatment is to have wastewater released

________________ without bad ______________ and ______________ of the stream.

3770 Technical Training Group
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-3b

POLLUTION CONTROL POLICIES AND PROGRAM

OBJECITVE

Given information related to hazardous waste material, select the phrase or term which correctly answers the written statements. Seven of the ten must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check contains ten items. You must answer seven correctly in order to receive a satisfactory rating.
2. When you have completed this progress check return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Complete the statements in Column A by selecting the proper term or phrase from Column B. Answers may be used once, more than once or not at all.

COLUMN A

1. The eight most common problems in hazardous wastes are:

   ______
   ______
   ______
   ______
   ______
   ______
   ______
   ______

2. Methods used to treat hazardous wastes are:

   a. _____
   b. _____

3. When areas of the body come in contact with hazardous chemicals, one should wash the contact area for ____________________.

4. To protect the health and comfort of the public, sewage must be ____________, ______________, and ______________ without creating a nuisance or health hazard.

5. Solvents in water will cause ________ and ________ problems

6. Pesticides and herbicides are ____________ to man and to living organisms.

7. Grease and oil in wastewater can be controlled by _______________ or ______________ methods.

COLUMN B

a. Collected

b. Soluable organics

c. Taste

d. Heat

e. 15 min to 2 hours

f. Odor

g. Soluable minerals

h. Treated

i. Substances that burn and explode

j. Poisonous

k. Toxic substances

l. Chemical treatment

m. Disposed

n. Color and turbidity

o. 5 min to 1 hour

p. Oil, grease, scum

q. Physical treatment

8. A sudden discharge of heated water, thermal pollution, to bodies of water can effect ___________ life.

9. Excessive detergents may cause ____________ in aeration tanks.

10. Acids and alkalines can be treated by ____________.

r. Acids and alkalines

s. Fish and shell

t. Frothing

u. Chemical

v. Neutralization

3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-4a

OPERATION AND MAINTENANCE OF SEPTIC TANKS

OBJECTIVE

Given a list of statements concerning the construction features; operational practices and maintenance of septic tanks, complete each statement. Ten of fifteen must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check contains fifteen items. You must answer ten correctly in order to receive a satisfactory rating.
2. When you have completed this progress check return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Complete the following statements in Column A with the correct term or phrase is Column B. The term or phrase may be used once, more than once or not at all.

COLUMN A

1. Small septic tanks should have capacity to detain wastewater for ____________ hours.
2. From ______ to _______ percent of suspended solids remain in the septic tank effluent.
3. A title field consists of __________ in the ground with _________ _________ used to dispose of settled wastewater into the ground.
4. For proper function of a tile field the water table must be _______ the level of the tile field.
5. Placing tile _____ the frost line to prevent freezing is NOT necessary.
6. Pipe size from _____ to _____ inches in diameter is recommended for tile fields.
7. Tile pipe should be laid to a true ______ and ______.
8. Trenches in clay soil with a mixture of gravel should be ___________ than soil composed of sand or loom.
9. Tile fields may be protected against crushing by erecting ________ or _________.
10. A dosing siphon is a ______ device that ______ wastewater from the primary to the secondary system.
11. Inspection of septic tanks should be inspected at periods of _______ flows.

COLUMN B

a. line, grade
b. Pipe (line)
c. smaller
d. 40 - 60
e. less
f. below
g. 24
h. open joints
i. fences
j. 4, 6
k. transfers
l. wider
m. posts
n. high
o. manholes
p. mechanical
q. sludge, scum

12. Sludge removed from a septic tank may be disposed of by ____________________.

13. The addition of chemicals to septic tanks _______ recommended.

14. Records of septic tanks include data about _______ and ____________________.

15. Septic tanks may be used at __________ installations.

r. are not

s. burial

t. are

u. small

3770 Technical Training Group
(Civil Engineering Training)
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-5a

OPERATION AND MAINTENANCE OF PRETREATMENT UNITS

OBJECTIVE

Given information pertaining to pretreatment units and processes, match the terms and phrases to each type of processing unit. Ten of fifteen must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check contains fifteen items. You must answer ten correctly in order to receive a satisfactory rating.
2. When you have completed this progress check return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Complete the following statements in Column A with the correct term or phrase from Column B.

COLUMN A

1. Grease removed from grease traps is usually _______ or _________ .
2. All drains from flightlines, motor pools and other activities that discharge oily wastes must have _____ ________ installed at each effluent.
3. Three types of piping systems designed to carry wastewater to the plant are ________, ________, and ____________________.
4. A device installed in the collection system to prevent damage to plant equipment or clogging of wastewater lines is a ___________.
5. Wastewater collection system starts in a building and then empties into a ________ pipe.
6. The ________ or ________ sewer is, a large pipe which receives the flow from sub-mains and laterals.
7. Wasterwater collection systems use mostly ________ ______________ to move the wastewater.
8. The amount of wastewater than can be carried depends on the __________ and __________ of the pipe.
9. A _________ _________ must never be allowed between the sewer and drinking water lines.
10. A __________ is used to let the operator inspect and clean the sewer lines.
11. Four common problems with the operation of collection system are ___________, ___________, ___________ and ________________.
12. Lift stations are used where ___________ flow is not possible.
13. A _________ ________ is used to hold incoming liquds.

COLUMN B

a. sanitary sewers
b. manhole
c. burned
d. main, trunk
e. infiltration
f. storm sewers
g. gravity flow
h. buried
i. breaks/leaks
j. oil traps
k. odor
l. combined sewers
m. lateral
n. size, shape
o. screen
p. rainfall
q. cross-connection
r. roots
s. gravity
t. grease/trash
u. dry well

COLUMN A	COLUMN B
14. A _______ ________ is used to house equipment for inspection and maintenance.	v. grit
	w. wet well
15. Pumps used at lift stations are usually _____ or _____ type.	x. centrifugal, ejector

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PC J3ABR56631 000-IV-6a

OPERATION AND MAINTENANCE OF PRELIMINARY TREATMENT UNITS

OBJECTIVE

Demonstrate a knowledge of the purpose of preliminary treatment units and subsystems by making written responses to questions that pertain to preliminary wastewater treatment. Seven of ten responses must be correct.

REFERENCES/EQUIPMENT/MATERIALS

SW J3ABR56631 000-IV-1 thru 11
AFM 91-32

INSTRUCTIONS:

1. This progress check contains ten items. You must answer seven correctly in order to receive a satisfactory rating.
2. When you have completed this progress check return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Use your study guide/workbook and AFM 91-32 to write short statements answering each question.

1. What is the purpose of a bar screen? ______________________________

____

2. Coarse screens are used to remove what type of solids? ______________________
3. Fine screens are used to remove what type of solids? ______________________
4. What two methods are used to clean bar screens? ______________________

____

5. What is the purpose of grit removers (chambers)? ______________________

____

6. What is the purpose of a shredder, grinder of comminutor? ______________________

____

7. What is the recommended preaeration period? ______________________
8. How is grease removed from wastewater during the preaeration process? __________

____

9. What type materials is removed when using vacuum flotation? ______________
10. What device is used to measure flow in open channels? ______________________

____

3770 Technical Training Group
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PC J3ABR56631 000-IV-6b

OPERATION AND MAINTENANCE OF PRELIMINARY TREATMENT UNITS

OBJECTIVE

Using information provided, list the required maintenance for screens, grit removers, shredders and preaerators according to AFM 91-32. Six of ten must be correct.

REFERENCES/EQUIPMENT/MATERIALS

AFM 91-32

INSTRUCTIONS:

1. This progress check contains ten items. You must answer six items correctly in order to receive a satisfactory rating.
2. When you have completed this progress check return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Use AFM 91-32 to answer the following questions pertaining to the maintenance of preliminary treatment units?

1. How often should bar screens (trash racks) be inspected and raked? ____________
2. How should screenings (rags, etc.) be disposed of properly? ________________
3. Three maintenance requirements performed on mechanically cleaned bar screens are ____________________, ________________ and ______________________.
4. What are the maintenance requirements for proper operation and care of comminutors and barminutors? ____
   ____
5. What action is taken if the sharpening and realigning of cutting edges on a comminutor fail to give good results? ______________________________________
   ____
6. What daily inspections are performed on aerated grit chambers? ______________
   ____
   ____
7. What action should be taken if sand, silt and gravel are found in the primary clarifier? ____
   ____
   ____

8. What is the likely cause of a comminutor or bariminutor not operating? ____________

____

____

9. What action should be taken if improper shredding or unusual vibrations and noise is noticed from a comminutor or barminutor? ____________________________

____

____

10. What action should be taken if ice has coated the machinery tracks and guides?

____

____

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Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-6c

OPERATION AND MAINTENANCE OF PRELIMINARY TREATMENT UNITS

OBJECTIVE

Using AFM 91-32, solve three operational problems concerning the preaeration unit on the preliminary treatment process.

REFERENCES/EQUIPMENT/MATERIALS

AFM 91-32

INSTRUCTIONS:

1. This progress check contains three items. You must answer all of them in order to receive a satisfactory rating.
2. When you have completed this progress check return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Below are three operational problems concerning the preaeration unit of preliminary treatment process. You may use AFM 91-32 to obtain the solution.

1. What determinines if preaeration is required?
2. What purpose does preaeration serve?
3. If a preaeration unit contains no air bubbles, what is this an indication of?

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PC J3ABR56631 000-IV-6d

OPERATION AND MAINTENANCE OF PRELIMINARY TREATMENT UNITS

OBJECTIVE

While on a field trip to a local municipal wastewater treatment plant, monitor the operation of the grip remover and screen/shredder. Use a checklist to evaluate procedures against the standards set forth in AFM 91-32. Student's checklist must correspond to 60% of the entries made by the instructor's evaluation of each item.

REFERENCES/EQUIPMENT/MATERIALS

AFM 91-32

INSTRUCTIONS:

1. This progress check will be accomplished under actual field conditions at a local wastewater plant.
2. Using the attached checklist, you must actually evaluate the operation of the items listed on the checklist.
3. Your answers must correspond to 60% of the evaluation of the instructor's assessment of the operation.
4. When you have completed this progress check, return it to your instructor.
5. If you have no questions, begin your progress check.

DIRECTIONS:

As a wastewater plant operator, you must be aware of the changing conditions effecting the efficient operation of wastewater equipment. This progress check is designed to test your ability to recognize operational and maintenance areas concerning the equipment. Your instructor will be accomplishing a checklist also. Your checklist must agree within 60% of the instructor's checklist on each item in order to receive a satisfactory rating on this progress check.

GRIT REMOVERS

1. Is water entering the unit evenly?
2. Is the mechanical grit remover in operation?
3. Is pre-chlorination taking place in the grip chamber?
4. Are trash and rags left on the grip chamber chain?
5. Does unit have proper propertional wier?

SCREENS AND SHREDDERS

1. Is screen properly set for receiving flow?
2. Is screen raked and clean?
3. Are proper gates open to allow flow to enter the screen?
4. Are cleaning tools in a safe place?
5. Is Barmunuter in operation?

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PC J3ABR56631 000-IV-7a

OPERATION AND MAINTENANCE OF PRIMARY TREATMENT UNITS

OBJECTIVE

While visiting a municipal wastewater plant, observe the operation of the plant and equipment. Use a schematic to trace the flow through the system and a checklist to list the maintenance and safety items with no more than three instructor assists.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check contains three parts, consisting of nineteen items. You must answer all items correctly.

2. You are authorized three instructor assists.

3. When you have completed this progress check, return it to your instructor.

4. If there are no questions, begin your progress check.

DIRECTIONS:

Study the illustration of the sewage lift station at Wichita Falls, in figure 7-1, and place the number from the figure by the name of the component in the space provided.

_______ Measuring device

_______ Electric motors

_______ Air compressors

_______ Screens and shredders

_______ Wet well

_______ Control panel

_______ Pumps

_______ Ventilation

_______ Swing lift valves

_______ Fresh water tank

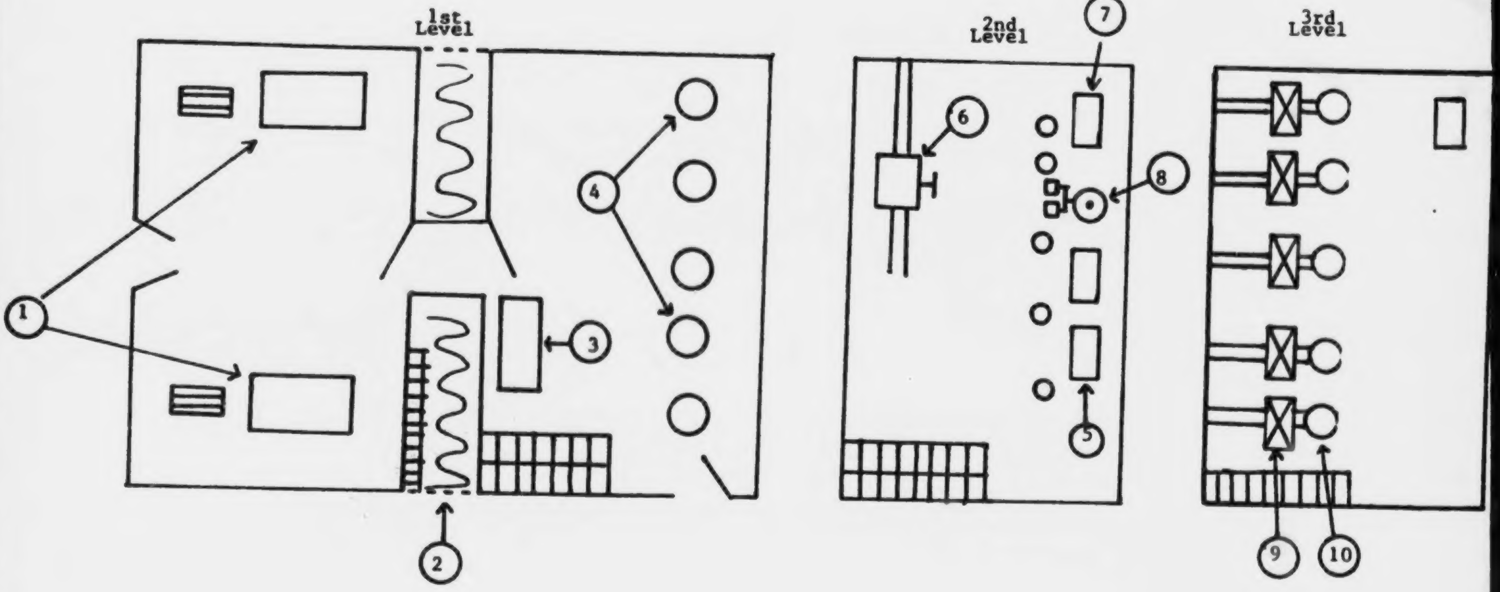
1st Level
2nd Level
3rd Level
1
2
3
4
5
6
7
8
9
10

Figure 7-1. Lift Station

PART 2

INSTRUCTIONS

During the Field Trip list any discrepancies noted.

What discrepancies in operation and maintenance did you witness on the field trip?

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

PART 3

INSTRUCTIONS

Study the illustration of the 63 wastewater plant at Wichita Falls, Texas, in figure 7-2 and place the number from the figure by the name of the component in the space provided. Some names are used more than once.

____ Grit chamber

____ Distribution box

____ Sludge pump room

____ Primary clarifier

____ Secondary clarifier

____ Trickling filter

____ Primary disgester

____ Secondary digester

____ Sludge drying beds

____ Boiler room

____ Influent from lift-station

____ Effluent

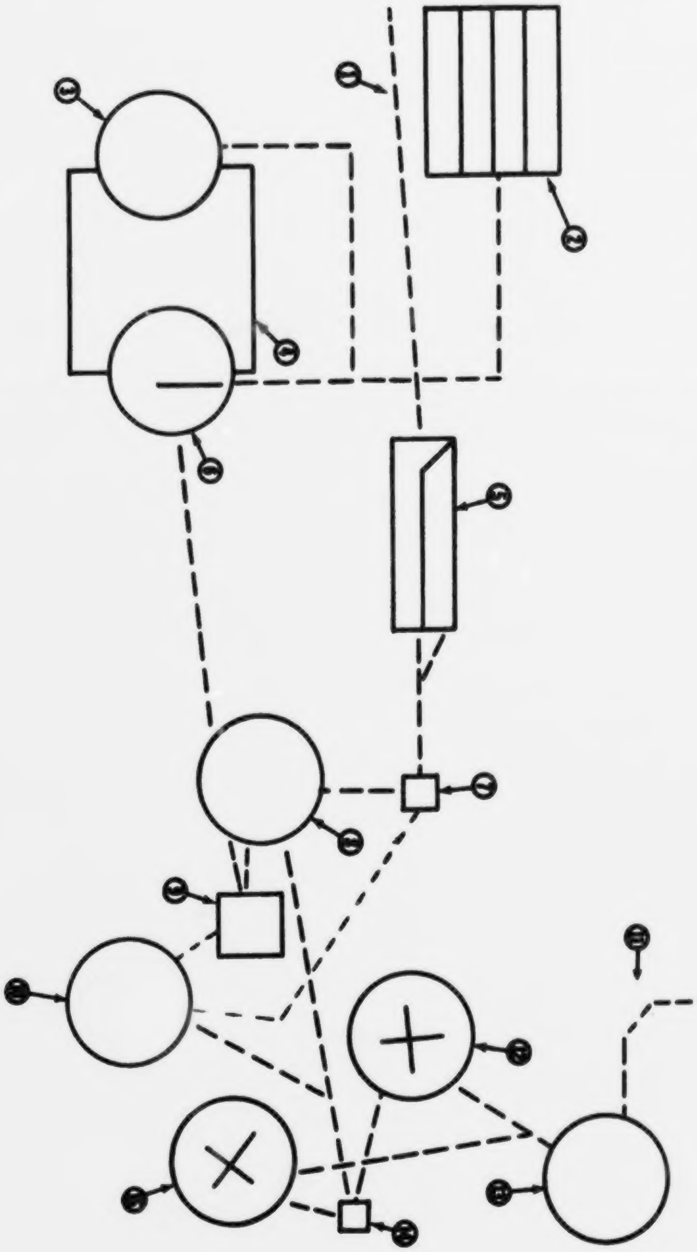

Figure 7-2. Wastewater Plant

_______________ STOP _______________

Before proceeding any further, have the instructor check your work.

________ Instr initials

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OPERATION AND MAINTENANCE OF PRIMARY TREATMENT UNITS

OBJECTIVE

Using given information, a sampling device and working as a team, collect a wastewater and a sludge sample from various sampling points within the plant, with no more than two instructor assists.

REFERENCES/EQUIPMENT/MATERIALS

AFM 91-32
Wastewater Sampler, (1 ea team)

INSTRUCTIONS:

1. This progress check consists of collecting wastewater and sludge samples. You must collect the samples in accordance with AFM 91-32.
2. Failure to follow the instructions will result in an unsatisfactory rating on this progress check.
3. When you have completed this progress check, return it to your instructor.
4. If you have no questions, begin your progress check.

DIRECTIONS:

While on the field trip to a wastewater plant, collect a wastewater sample and a sludge sample. In the space below write down where in the plant the sample was collected from.

WASTEWATER

SAMPLE	SAMPLING POINT
Raw	
Primary	
Secondary	
Final	

SLUDGE

SAMPLE	SAMPLING POINT
Raw	
Digestor	
Digested	

_______ Inst. initials

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OPERATION AND MAINTENANCE OF PRIMARY TREATMENT UNITS

OBJECTIVE

Following written instructions, identify the operation of primary wastewater treatment units by making written responses to questions according to AFM 91-32. Seven of the ten answers must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consists of ten units. You must answer seven of them correctly in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Complete the following questions which pertain to primary treatment by making short written statements to each question.

1. What are primary clarifiers (settling tanks) used for in wastewater treatment? ______________________________
2. What are the three types of settling tanks? ______________________________
3. How is sludge removed in primary settling tanks? ______________________________
4. What are three major construction features of an Imhoff tank? ______________________________
5. What are the three types of digesters? ______________________________
6. What is the purpose of a drying bed? ______________________________
7. Why is a fork recommended rather than a shovel when removing dried sludge from the drying beds? ______________________________
8. How can wet sludge be used or disposed? ______________________________
9. What is the purpose of a flame trap? ______________________________
10. What material is used on the media of a bacuum filter drum? ______________________________

OPERATION AND MAINTENANCE OF PRIMARY TREATMENT UNITS

OBJECTIVE

Following written instructions, list the maintenance practices of primary wastewater treatment units by making written responses to questions according to AFM 91-32. Eight of twelve responses must be correct.

REFERENCES/EQUIPMENT/MATERIALS

AFM 91-32

INSTRUCTIONS:

1. This progress check contains twelve items. You must answer twelve correctly in order to receive a satisfactory rating.
2. When you have completed this progress check return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Complete the following questions pertaining to the maintenance of primary treatment units by listing the corrective actions to take for each situation. You may use AFM 91-32 Chapters 4 and 13 for assistance.

1. What actions should be taken if settleable solids are passing over the effluent weir of a settling tank? ______________________________

   ____

2. What actions should be taken in cleaning the sidewalls of settling tanks? ________

   ____

3. What maintenance procedures are taken to care for "dead-ends" and corners of settling tanks? ______________________________

4. How is scum removed and disposed of during the care of an Imhoff tank? __________

   ____

5. How can floating solids and foam be controlled in the settling tank of an Imhoff tank? ______________________________

6. If the sludge outlet pipe of an Imhoff tank becomes clogged, what action should you take to unclog the line? ______________________________

   ____

7. What maintenance procedure should be taken if excess grit is accumulated in an anaerobic digester? ______________________________

   ____

8. What maintenance procedure should be taken if watery sludge is being discharged to the drying beds or units? ______________________________

____

9. If the underdrains of a drying bed is crushed or has collapsed, what maintenance actions should be taken? ______________________________

____

10. How often should the vacuum filter medium be cleaned? ______________________________

____

11. How is excess grease and oil removed from the filter? ______________________________

____

12. If odors and foaming is noticed around the parts of the filter, filter room and sludge lines, what maintenance action should be taken? ______________________________

____

OPERATION AND MAINTENANCE OF PRIMARY TREATMENT UNITS

OBJECTIVE

Given five statements concerning the grease and volatile acids test, indicate if the statements are true or false. Three of the five statements must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check contains five statements which you are to indicate whether they are true or false. You must answer three of the five correctly in order to receive a satisfactory rating.

2. If there are no questions, begin your progress check.

3. When you have completed this progress check, return it to your instructor.

DIRECTIONS:

Identify whether the following statements concerning grease and volatile acid tests are true or false by placing a "T" for true or an "F" for false in front of the statement.

1. _____ Volatile acid tests measure the acid content of the sludge.

2. _____ Volatile acid tests are valuable to maintain digester control.

3. _____ Volatile acid tests uses a hot plate as a piece of equipment needed to run the test.

4. _____ To run a lab grease test you must have at least 1000 ml of sample.

5. _____ Holding time for a grease test sample should not exceed 24 hours.

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PC J3ABR56631 000-IV-8a

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Given a list of incomplete statements and a list of terms and phrases relative to the operation of trickling filters, complete the statements IAW AFM 91-32. Eight of twelve completed statements must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consist of twelve items. You must correctly answer eight in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Complete the incomplete statements in Column A by using the terms or phrases in Column B. All selections can be used once, more than once or not at all.

COLUMN A

1. Trickling filters remove pollutants from wastewater by changing _____ and _______ solids to _____ sludge.
2. The film covering the filter media of a trickling filter is known as _______ layer or _________ film.
3. Trickling filters are part of the _________ process.
4. The type of bacteria mostly found to decompose solid matter on the trickling filter media is ____________.
5. Trickling filters remove solids by ________ action, not by filtration.
6. The four different classes of trickling filters are ___________, _________, __________, _______________.
7. The four main parts of a trickling filter are the ____________, ____________, ___________, and the ________________.
8. A trickling filter must have the right amount of _____________, ____________, and _________________ to change dissolved solids to settleable solids.
9 A trickling filter can remove up to __________ to ___________ percent of BOD.
10. Recirculation from the final clarifier back to the trickling filter is used to _________ the removal of ________ and _________________ solids.
11. Factors which can affect trickling filter operation are ________ and ______________ ______________.

COLUMN B

a. settleable
b. super-high-rate
c. slime
d. biological
e. dissolved
f. aerobic
g. roughing
h. zoogleal
i. distribution system
j. collodial
k. standard-rate
l. secondary
m. high-rate
n. media
o. food
p. ponding
q. 85-90
r. seasonal changes

12. Two types of distributor arms are ________ and ___________.

s. oxygen
t. rotary
u. underdrain
v. fixed
w. microorganisms
x. retaining wall
y. increase
z. temperature

3770 Technical Training Group
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Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-8b

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Given information and a troubleshooting guide, identify the maintenance requirements for trickling filters by following a troubleshooting guide with a maximum of one instructor assist.

REFERENCES/EQUIPMENT/MATERIALS

AFM 91-32

INSTRUCTIONS:

1. This progress check consists of five items. You must correctly answer all items in order to receive a satisfactory rating on this progress check.
2. You are authorized one instructor assist.
3. When you have completed this progress check, return it to your instructor.
4. If you have no questions, begin your progress check.

DIRECTIONS:

Use table 5-7 in AFM 91-32 and determine the action to take to correct the following operational problems in trickling filters.

OPERATIONAL PROBLEM/INDICATOR	ACTION TO TAKE
1. What action should be taken if there is grease on the filter media?	a. ______________________ ______________________ b. ______________________ ______________________
2. What action should be taken if leaking is noticed around the center column?	a. ______________________ ______________________ b. ______________________ ______________________
3. What action should be taken if the flow through the distributor arms are not uniform?	a. ______________________ ______________________ b. ______________________ ______________________

4. What action should be taken if an uneven splash or spray pattern is noticed coming from the filter arms?

a. ______________________________

____

b. ______________________________

____

5. What action should be taken if black growth and foul odor are noticed on the filter media?

a. ______________________________

____

b. ______________________________

____

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Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-8c

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Given information and incomplete statements related to wastewater lagoons, write the correct term or phrase to each statement according to AFM 91-32. Six of the ten responses must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consists of ten items. You must correctly answer six in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Select the correct term or phrase from Column B which applies to the incomplete statement in Column A.

COLUMN A

1. Bacteria in lagoons may be either ______, ______ or ______________.
2. Stabilizing organisms included in the processing of wastewater lagoons are ________, ________, ________, ________, and some fish.
3. A lagoon should be located at least ______________ from all water supplies.
4. Soil conditions for construction of lagoons should be ________________.
5. Some construction features of lagoons include __________________, ________________________, and ____________ bottoms.
6. Surrounding area of a lagoon should be kept free from __________ and ___________.
7. Cattails, burr reeds, and other shallow water plants should be controlled because they attract _________ and _________________.
8. A lagoon effluent below average may indicate _______ has developed.
9. What visual observations can indicate the operation efficiency of lagoons?

   a.
   b.

COLUMN B

a. algae, bacteria
b. dikes
c. one-fourth mile
d. weeds
e. aerobic
f. level
g. mosquitoes
h. protozoa, rotifers
i. clear effluent
j. anaerobic
k. sloped walls
l. pourous
m. muskrats
n. faculative
o. leakage or perculation
p. crustaceans, worms
q. brush

10. Tests for good operation and function of a lagoon include __________, __________, and ____________.

r. free-board space

s. insect larvae, amphibians

t. accesses, well maintained

u. pH, flow

v. no scum or grease

w. suspended solids

x. temperature, D.O.

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PC J3ABR56631 000-IV-8d

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Define the activated sludge process and principles by matching the correct phrase or term to a statement related to activated sludge. Seven of eleven responses must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consists of eleven items. You must correctly answer seven in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Select and match the statements from Column A with the terms and phrases in Column B which pertain to activated sludge processes or principles. Selections can be used once, more than once or not at all.

COLUMN A

____ 1. A biological unit or system used in secondary treatment.

____ 2. A system that can remove as much as 95% BOD.

____ 3. Affects the A.S. process more than some other systems.

____ 4. Mixes with the sludge already in the aeration tank.

____ 5. Enough supplied to keep the wastewater aerobic.

____ 6. Must be returned from the final settling tank to the aeration tank.

____ 7. The name of the contents in the aeration tank.

____ 8. The name of the liquid and solids that is sent back to the aeration tank.

____ 9. The name of the solids that are removed from the plant system.

____ 10. Organisms that do not settle well or do not form a heavy floc.

____ 11. Three nutrients required for A.S. process

COLUMN B

a. influent wastewater

b. waste sludge

c. sludge

d. floc-forming

e. activated sludge

f. phosphorous

g. mixed liquor

h. oxygen

i. microorganisms

j. carbon

k. shock loads

l. nitrogen

m. filamentous

n. returned activated sludge (RAS)

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Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-8e

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Indicate the basic facts about activiated sludge systems by matching the proper facts to a list of various types of systems. Twelve of seventeen must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consist of seventeen items. You must correctly answer twelve in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Match the following statements to the system they describe. The systems may be used once, more than once, or not at all.

STATEMENTS

1. _____ 8-12 hour aeration detention time
2. _____ Reaeration basin has a longer detention time than the aeration tank
3. _____ May include a primary settling tank
4. _____ Oxidation ditch
5. _____ May use rotors to aerate the mixed liquor
6. _____ Microorganisms live on rotating discs
7. _____ May be shaped in a circular construction similar to package plants
8. _____ Operates with a very old sludge age
9. _____ Separated into stages of treatment
10. _____ Cement-asbestos plates
11. _____ Has a short detention time for the wastewater
12. _____ Mixing zone, reaeration zone, aerobic digester, settling zone
13. _____ Uses only diffused aeration process
14. _____ Requries R.A.S. for seeding the aeration tank.
15. _____ Uses an intermediate settling tank
16. _____ Detention time is at least 18 hours
17. _____ Does not require a digester

SYSTEM

a. RBC
b. Conventional
c. Extended aeration
d. Contact stabilization
e. Submerged contact aeration

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-8f

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Indicate the corrective action to take when operational problems develop by listing the proper corrective action for each problem according to AFM 91-32. Two of four must be correct.

REFERENCES/EQUIPMENT/MATERIALS

AFM 91-32

INSTRUCTIONS:

1. This progress check consists of four items. You must correctly answer two in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Write the corrective action you should take to correct the operational problems listed below. Use AFM 91-32 for assistance. Problems will pertain to activated sludge aeration tanks, settling tanks for organic/hydraulic loading of the system.

PROBLEM	CORRECTION
1. Odors are devloping in the aeration tank.	
2. A white fluffy foam is noticed in the aeration tank.	
3. A large and sudden decrease in solids in the final clarifier is noticed.	
4. Clumps of sludge are rising to the surface of the aeration tank and the D.O. has dropped - an odor is noticed. Presume an organic overload in aeration tank.	

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Match a list of incomplete statements concerning submerged contact aeration units with the correct term to complete them. Three of the five statements must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consists of five items. You must correctly answer three in order to receive a satisfactory rating on this progress check.
2. If you have no questions, begin your progress check.
3. When you have completed this progress check, return it to your instructor.

DIRECTIONS:

Complete the statements in Column A with the words or phrases in Column B. Selection may be once, more than once or not at all.

Column A

1. _____________ are used to distribute air evenly throughout the basin.
2. The foam on top of a contact aeration plant can be controlled by a fine spray of _______________________.
3. The color of mixed liquor in a wastewater plant is _______________.
4. The type of bacteria in a contact aeration plant is ________________.
5. Dissolved oxygen in a contact aeration system is kept between _____________ and ____________________.

Column B

a. 1 ppm and 3 ppm
b. Water
c. Brown
d. Aerobic
e. Diffusers
f. Green
g. Anaerobic
h. 3 ppm and 5 ppm
i. Gray
j. Chlorine
k. Air
l. Oil

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Given five statements concerning a rotating fixed media biological unit, indicate if the statements are true or false. Three of the five statements must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consists of five items. You must correctly answer three in order to receive a satisfactory rating on this progress check.
2. If you have no questions, begin this progress check.
3. When you have completed this progress check, return it to your instructor.

DIRECTIONS:

Below are five statements concerning a rotating fixed media biological unit. Indicate if the statement is true or false by placing a T for True and an F for false in the space provided in front of the statement.

1. _____ The reactor is submerged a little less than halfway in the wastewater.
2. _____ The speed of the reactor is 2-4 rpm.
3. _____ The biological process of the rotating biological reactors do-not require pretreatment.
4. _____ The growth on the rotating media is called bio-mass.
5. _____ Solids separation is normally accomplished in a conventional final settling tank.

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-81

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Using AFM 91-32 and given a list of statements concerning wastewater plant safety, correct the statements which are false. Seven of ten must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consists of ten items. You must correctly answer seven in order to receive a satisfactory rating on this progress check.

2. When you have completed this progress check, return it to your instructor.

3. If you have no questions, begin your progress check.

DIRECTIONS:

Below are ten statements containing information which is false. Correct the statements so they state a true fact.

1. Oxygen deficiency is a minor hazard in wastewater collection system.

2. Personally turn off and tag all power equipment before starting any maintenance.

3. Entering any below-ground level area where gases may have collected requires a filter wash.

4. Emergency electrical first aid consists of two basic steps.

5. Your first move is to turn off and tag all power from any electrical component.

6. Always start a positive displacement pump against a closed discharge valve.

7. Work alone while mowing or burning vegetation.

8. Apply water to a chlorine leak as this will indicate the leak.

9. Maintain slip surfaces on all ladders, stairs and catwalks.

10. On duty operators should be expected to interrupt their work to act as safety guides for visiors.

11. When you must lubricate a machine while it is operating. The fittings should be at least 6" from any moving part.

12. Sludge digesters are comparatively safe when empty, but more dangerous when partially filled.

3770 Technical Training Group
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Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-8j

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

While visiting a municipal wastewater plant, observe the operation of the plant and equipment. Use a schematic to trace the flow and identify the components. Use a checklist to list the maintenance and safety items with no more than three instructor assists.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consist of three parts. You must correctly answer all parts order to receive a satisfactory rating on this progress check.

2. You are authorized three instructor assists.

3. When you have completed this progress check, return it to your instructor.

4. If you have no questions, begin your progress check.

DIRECTIONS:

Complete each diagram pertaining to the different plants observed while on the field trip. Trace the flow and identify the plant components.

Part I Burkburnett

II Electra

III Iowa Park

PROGRESS CHECK IV-8j (Cont'd)

Figure 8-1. Burburnett

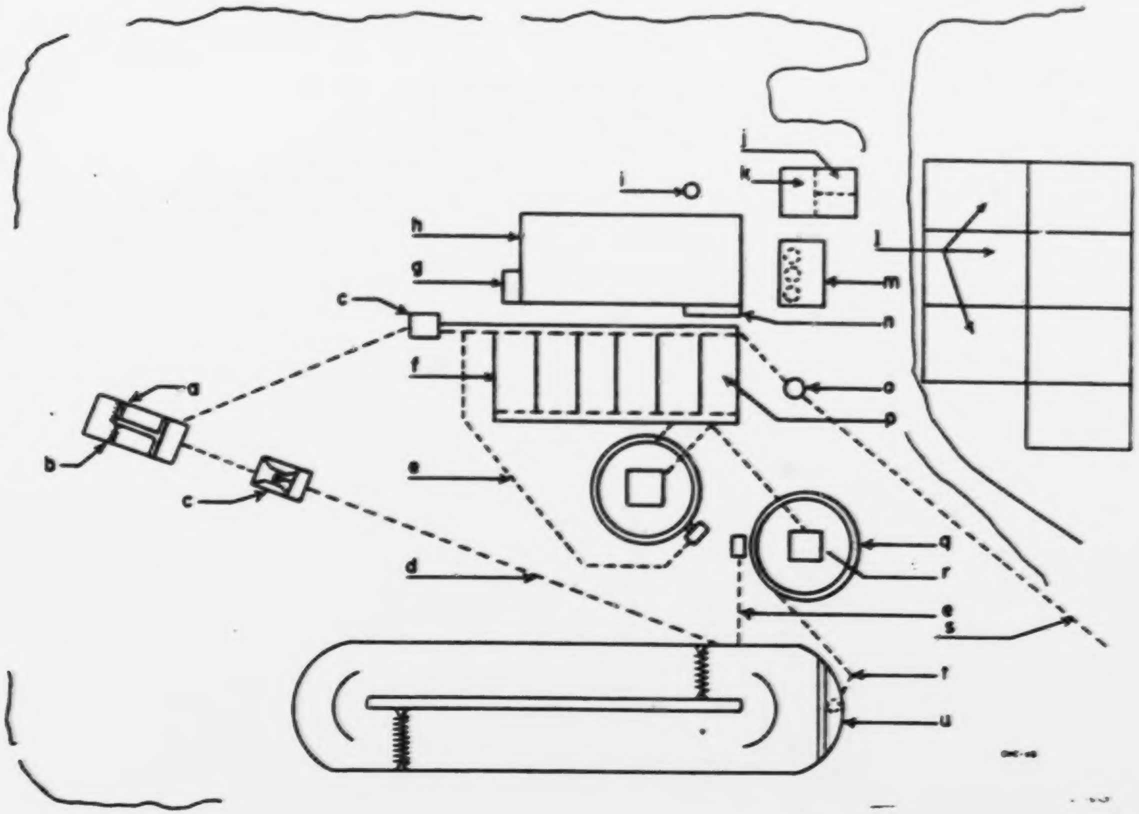


Figure 8-1. Burburnett

1. ______ Laboratory
2. ______ Office
3. ______ Drying beds
4. ______ gas burner
5. ______ anaerobic digester
6. ______ pumps to digester
7. ______ supernatant tanks
8. ______ blowers
9. ______ barmuttior
10. ______ bar screens
11. ______ parshell flume
12. ______ line to oxidation ditch
13. ______ final clarifier for new plant
14. ______ A.S. return line (old plant)
15. ______ A.S. return line (new plant)
16. ______ oxidation ditch
17. ______ line to river
18. ______ weirs
19. ______ chlorine contact tank
20. ______ plant effluent
21. ______ aeration tanks
22. ______ mixed liquor flow

Figure 8-1. Burkburnett Plant

PROGRESS CHECK IV-8j (Cont'd)

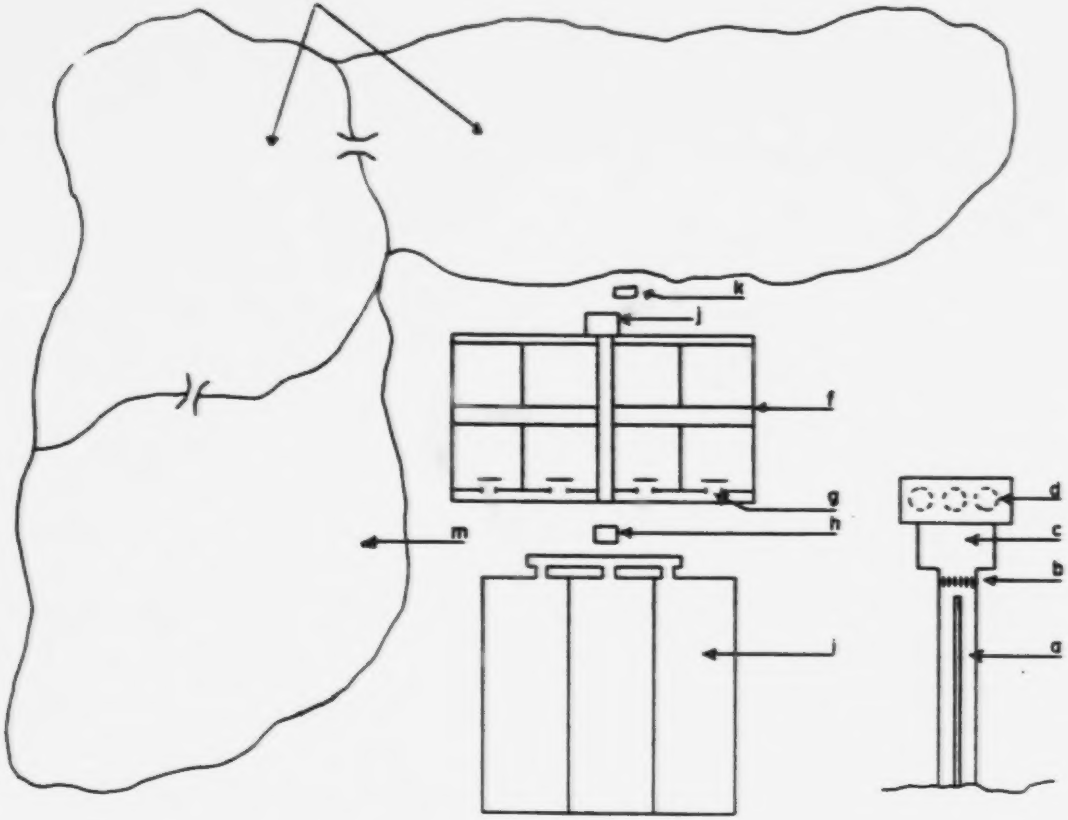


Figure 8-2. Electra

1. ______ Oxidation ponds
2. ______ Imhoff Tanks
3. ______ primary effluent
4. ______ recirculation box
5. ______ office
6. ______ lift station
7. ______ drying beds
8. ______ sludge valves
9. ______ Imhoff influent
10. ______ grit chamber
11. ______ bar screen
12. ______ wet well
13. ______ discharge to ponds

Figure 8-2. Electra Plant

PROGRESS CHECK IV-8j (Cont'd)

Figure 8-3. Iowa Park

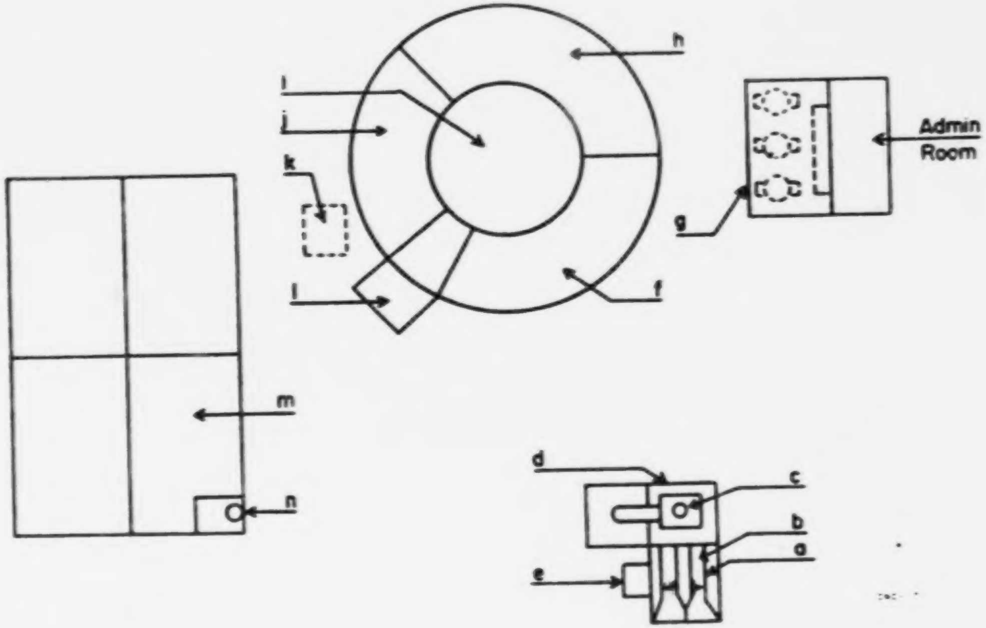


Figure 8-3. Iowa Park

1. ______ Drying bed

2. ______ bar screen

3. ______ contact tank

4. ______ reaeration tank

5. ______ blowers

6. ______ underdrain sump

7. ______ chlorination room

8. ______ grit chamber

9. ______ aerobic digester

10. ______ pump room

11. ______ parshall flume

12. ______ final clarifier

13. ______ measuring device

14. ______ grit pump

Figure 8-3. Iowa Park Plant

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-8k

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Given information related to laboratory test controls of an activated sludge system, identify the type and reason for each test control according to AFM 91-32. Four of six must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consists of six items. You must correctly answer four in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Identify the A.S. control test by selecting the correct test for each fact or phrase listed below. Test items can be used once, more than once, or not at all.

FACT OR PHRASE

_________ 1. Can help the operator identify organisms which may cause problems.

_________ 2. Relates the weight of sludge to the volume the sludge occupies.

_________ 3. Solids retention time, or the average time the organisms remain in the system.

_________ 4. The volume in mLs taken up by one gram of sludge after 30 minutes of settling.

_________ 5. Indicates the concentration of oxygen in aneration tank.

_________ 6. It is used to determine the concentration of solids in the aeration tank.

TEST

a. Dissolved Oxygen (D.O)
b. Sludge Age (S.A.)
c. Sludge Volume Index (SVI)
d. Sludge Density Index (SDI)
e. Mixed Liquor Suspended Solids (MLSS)
f. Microscopic examination

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-81

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Given information and a troubleshooting guide, identify the maintenance requirements for each activated sludge system by selecting the correct action to take. Three of five must be correct.

REFERENCES/EQUIPMENT/MATERIALS

AFM 91-32

INSTRUCTIONS:

1. This progress check consist of five items. You must correctly answer three in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Use the troubleshooting guide in AFM 91-32 and your study guide to select the correct maintenance action to take for each statement listed below.

1. How can grease and scum be prevented from entering the aeration tank of a contact aeration system?

2. How often are the following items of a RBC plant checked or inspected for preventive maintenance?

ITEM	INSPECTION
a. unusual noise, vibration, heat	
b. smooth disc rotation	
c. lubrication	
d. chain drives and alignment	

3. If septic conditions are noted in the primary tank of a conventional A.S. plant, what maintenance action should be taken?

4. If septic conditions are noticed in the final clarifier of a contact stabilization plant, what action should be taken?

5. What action should be taken if the rotors of an extended aeration, oxidation ditch are not working?

OPERATION AND MAINTENANCE OF SECONDARY TREATMENT UNITS

OBJECTIVE

Working as a team and using a schematic to operate the wastewater plant trainer, locate the correct valves to control the flow of water through each processing unit with no more than five instructor assists.

REFERENCES/EQUIPMENT/MATERIALS

Wastewater Plant Trainer

INSTRUCTIONS:

1. This progress check consists of operating the wastewater trainer. You must follow the instructions in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Work as a team and follow the checklist for operating the wastewater trainer. Use the diagram to locate and identify the valves according to each plant unit. The instructor will be available for assistance and direction.

__________ Instr initials

WASTEWATER TREATMENT TRAINER CHECKLIST

Open the valve or valves to start a flow of wastewater through the trainer.

a. Check all valves on the trainer and be sure they are closed.

b. Start the flow through the grit chamber, bar screen, and the comminutor by opening valve number 11.

c. Open valve number 13 so flow will fill the Imhoff tank.

d. Open valves number 17 and number 19 to remove sludge from Imhoff tank, open valves number 10, number 1, 2, 3, and 4 to get sludge to drying beds from Imhoff tank.

e. When completed with project, drain the Imhoff tank by opening valve number 18 and closing valve number 13. Be sure valve number 12 is open and valve number 11 is shut off.

f. Repeat step b.

g. Open valve number 14 and begin flow through primary settling tank.

h. Fill primary settling tank, operate skimmer and sludge collector. Draw sludge to digester from primary settling tank by opening valve number 21, valve number 8 will be opened to remove sludge from digester when it has filled. Make sure valves number 1, 2, 3, and 4 are open.

i. When this is completed, open valves number 10 and number 16 to drain system.

j. Be sure valve number 22 is open for effluent to go to the trickling filter.

k. Then transfer wastewater from trickling filter to secondary settling tank by opening valve number 25, then activate pump.

l. Drain trickling filter and secondary settling tank by opening valve number 24 and 26.

m. Open all valves at this time for trainer to drain.

n. Leave valves open to allow for drainage of trapped water, reducing corrosion.

LIST OF VALVE NUMBERS

Pretreatment ______________________________

Preliminary treatment ______________________________

Primary treatment ______________________________

Secondary treatment ______________________________

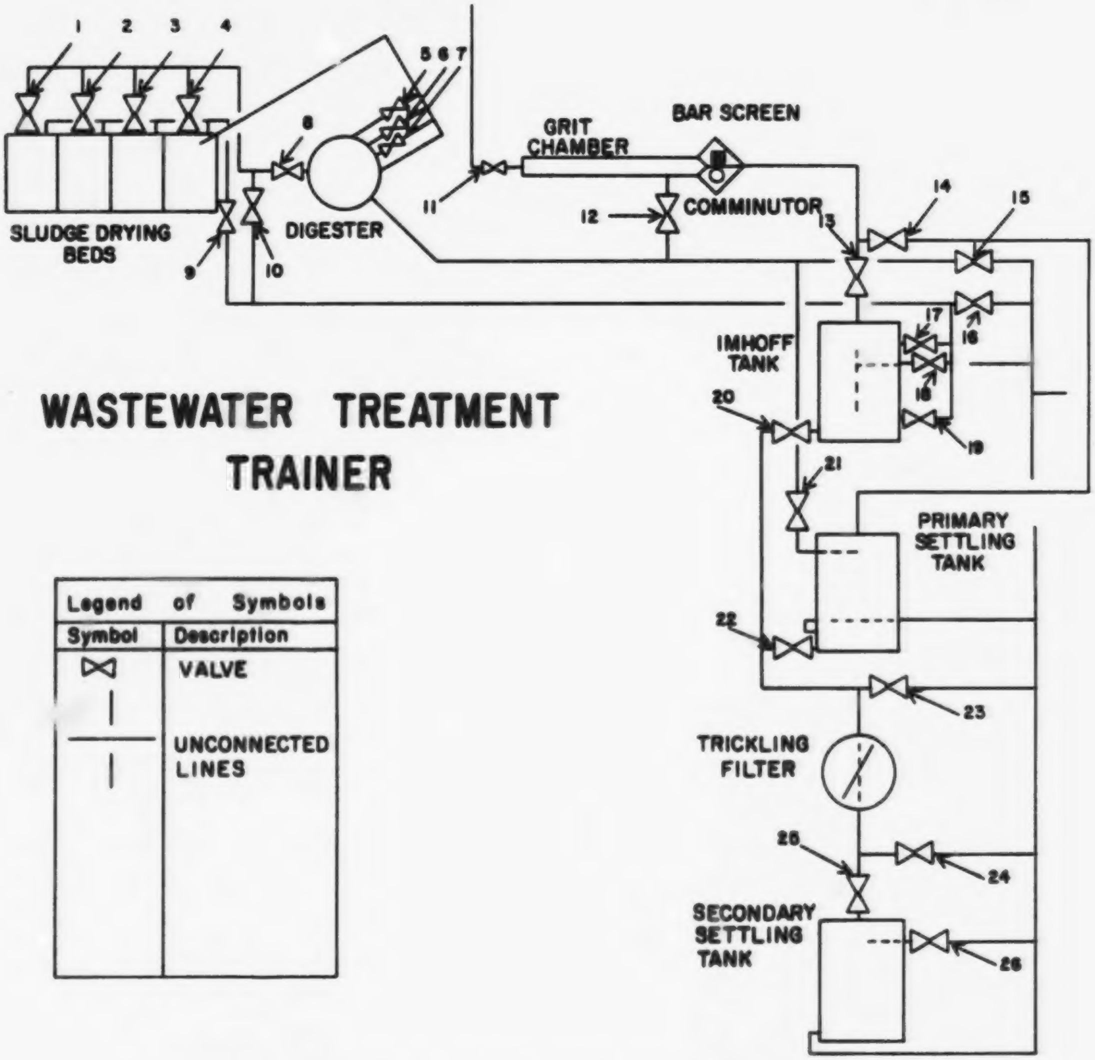

1
2
3
4
5 6 7
8
GRIT CHAMBER
BAR SCREEN
COMMINUTOR
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
SLUDGE DRYING BEDS
9
10
DIGESTER
IMHOFF TANK
PRIMARY SETTLING TANK
TRICKLING FILTER
SECONDARY SETTLING TANK
WASTEWATER TREATMENT TRAINER
Legend of Symbols
Symbol
Description
VALVE
UNCONNECTED LINES

Figure 8-4. Wastewater Treatment Trainer

______________ STOP ______________

Before proceeding any further, have the instructor check your work.

________ Instr initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-9a

TERTIARTY (ADVANCED) TREATMENT

OBJECTIVE

Given a list of incomplete statements and a list of terms and phrases related to advanced wastewater treatment, select the correct term or phrase that pertains to each statement. Seven of ten selections must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consists of ten items. You must correctly answer seven in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Complete the statements listed below by selecting the correct term or phrase. Selections may be used once, more than once or not at all.

STATEMENT

1. Advanced wastewater treatment will remove ______ and ______ solids.
2. The three treatment processes that can be used in AWT are ______, ______, and ______.
3. Basic units in AWT systems can include ______, ______, ______, ______, ______, and ______ ______.
4. Three chemicals used to help remove heavy metals in AWT are ______, ______ and ______.
5. Seven of twelve types of AWT are ______, ______, ______, ______, ______, ______ and ______.

TERM/PHRASE

a. coagulation
b. nitrogen
c. coagulant aids
d. microscreening
e. biological
f. filters
g. flocculation
h. stainless steel
i. lime
j. plastic fabric
k. denitrification
l. chemical
m. sedimentation
n. ion exchange
o. filtration
p. physical

6. Organic polymers are used as ________ __________.

7. Filters can remove ____________ and ______________ solids from wastewater.

8. Microscreens or microstraining are _________, which are made of __________________ or ________________ __________________.

9. Carbon filters are used to remove _______ matter.

10. Dentrification is the reduction of _____ to _____ and then to ___________ gas.

q. activated carbon
r. ferric chloride
s. organic
t. suspended
u. Electro-dialysis
v. carbon absorption
w. collodial
x. reverse osmosis
y. aluminum-sulfate
z. nitrate
aa. nitrite

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-9b

TERTIARTY (ADVANCED) TREATMENT

OBJECTIVE

Given information and a troubleshooting guide, and four problems, list one corrective operational or maintenance procedures for a phosphate tank, denitrification unit and a carbon filter IAW AFM 91-32. Two of four procedures must be correct.

REFERENCES/EQUIPMENT/MATERIALS

AFM 91-32

INSTRUCTIONS:

1. This progress check consists of four items. You must correctly answer two in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Use AFM 91-32, table 14-5 to answer the following questions which pertain to the operational and maintenance problems of the AWT units.

PROBLEM	CORRECTION
1. Chemical feed units are not running.	
2. Poor floc in the phosphate precipitation tank.	
3. Two many suspended solids in the effluent of an activated carbon unit.	
4. The condition of wastewater in the denitrification unit is turning septic; pH is 5.8.	

_______________ STOP _______________

Before proceeding any further, have the instructor check your work.

________ Instr initials

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-10a

DISINFECTION PROCESS

OBJECTIVE

Given a schematic of a wastewater plant, identify the points where chlorine may be applied and complete written statements related to wastewater disinfection. All chlorination points must be identified and ten of the fifteen completed statements must be correct.

REFERENCES/EQUIPMENT/MATERIALS

None

INSTRUCTIONS:

1. This progress check consists of one schematic and 15 incomplete statements. You must correctly accomplish the schematic and answer 10 of the 15 statements in order to receive a satisfactory rating on this progress check.
2. When you have completed this progress check, return it to your instructor.
3. If you have no questions, begin your progress check.

DIRECTIONS:

Answer the following questions pertaining to disinfection. Complete the diagram by indicating the chlorination application points within a treatment plant.

1. What color is chlorine gas? ______________________________

2. What type of material is most often used for feeder lines on gas chlorinators?

____

____

3. Other than disinfection, what other reason can chlorine be used ahead or within the wastewater plant? ______________________________

____

4. Why would chlorine be used in a settling basin? ______________________________

____

5. Why would chlorine be added to trickling filters? ______________________________

____

6. Why would chlorine be added to an activated sludge system? ______________________________

____

7. What are the four forms of chlorine used in wastewater treatment?

____

8. How should 150 lb. chlorine gas cylinders be stored? ______________________________

____

9. What are the four steps used for handling the 150 lb. chlorine cylinders? ________

____

____

10. What type of gasket material is used to make a seal between cylinder valve and chlorinator? ____

11. What should be checked before opening the chlorine cylinder valve? ____________

____

12. If not enough chlorine gas is being discharged to meet the demand, what action should be taken? ____

____

13. What other types of disinfectants may be used at treatment plants? ____________

____

____

14. What procedure should be taken when performing maintenance on chlorine equipment?

____

____

15. Use the diagram below to identify the points where chlorine may be applied for a specific reason or treatment by drawing an arrow at the point of application.

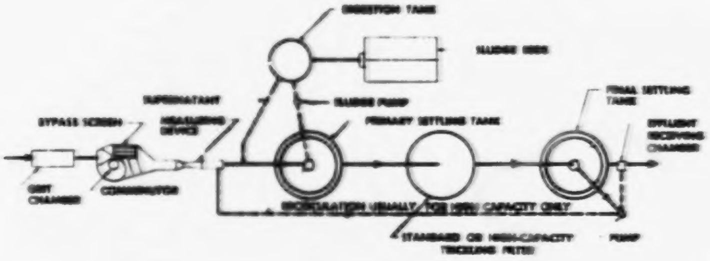

DIGESTION TANK
SLUDGE BEDS
SUPERNATANT
SLUDGE PUMP
BYPASS SCREEN
MEASURING DEVICE
PRIMARY SETTLING TANK
FINAL SETTLING TANK
EFFLUENT RECEIVING CHAMBER
GRIT CHAMBER
COMMINUTOR
RECIRCULATION USUALLY FOR HIGH CAPACITY ONLY
STANDARD OR HIGH-CAPACITY TRICKLING FILTER
PUMP

Figure 10-1.

3770 Technical Training Group
Civil Engineering Training
Sheppard Air Force Base, Texas

PC J3ABR56631 000-IV-11a

LOGS AND REPORTS

OBJECTIVE

Given pertinent data about a wastewater plant and AF Forms 1462 and 1463, complete the forms. Four of the seven entries must be correct.

REFERENCES/EQUIPMENT/MATERIALS

AF Form 1462
AF Form 1463
AFM 91-32

INSTRUCTIONS:

1. This progress check consists of seven items. You must solve four items correctly to receive a satisfactory rating.

2. When you have completed this progress check, return it to your instructor.

3. If you have no questions, begin your progress check.

DIRECTIONS:

Complete the following questions pertaining to logs and reports. Fill in the information asked for on AF Form 1462 and AF Form 1463. Four of seven must be correct.

1. Most information pertaining to plant operation and maintenance is gathered from what source? ______________________________

2. Using an AF Form 1462, what is the maximum, minimum and average influent pH reading? ______________________________

3. Using an aF Form 1462, what are the settleable solids readings for 19 June 1957?

____

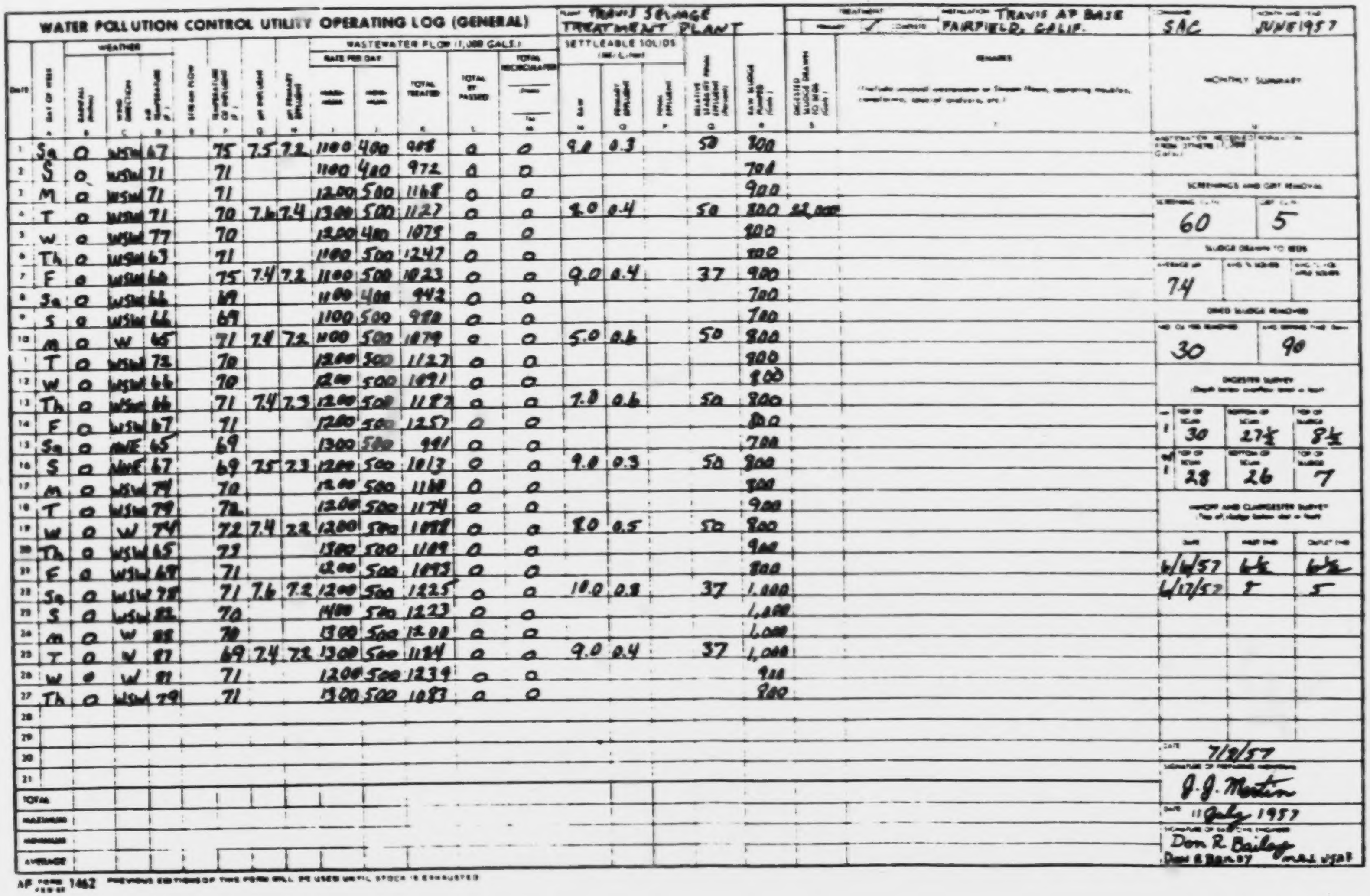
4. Using an AF Form 1463, what is the maximum, minimum and average raw BOD readings?

____

5. AF From 1462 is prepared in _________ and posted _____.

6. AF Form 1462 is reviewed monthly by the __________________.

7. The second copy of the 1462 is forwarded to __________.



WATER POLLUTION CONTROL UTILITY OPERATING LOG (GENERAL)

Plant: TRAVIS SEWAGE TREATMENT PLANT
Treatment: Primary ✓ Complete
Installation: TRAVIS AF BASE FAIRFIELD, CALIF.
Command: SAC
Month and Year: JUNE 1957

DATE		WEATHER							WASTEWATER FLOW (1,000 GALS.)					SETTLEABLE SOLIDS						REMARKS
									RATE PER DAY		TOTAL TREATED	TOTAL BY PASSED	TOTAL RECIRCULATED	RAW						
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	Sa	0	WSW	67		75	7.5	7.2	1100	400	908	0	0	9.0	0.3		50	800		
2	S	0	WSW	71		71			1100	400	972	0	0					700		
3	M	0	WSW	71		71			1200	500	1168	0	0					900		
4	T	0	WSW	71		70	7.6	7.4	1300	500	1127	0	0	8.0	0.4		50	800	22,000	
5	W	0	WSW	77		70			1200	400	1075	0	0					800		
6	Th	0	WSW	63		71			1100	500	1247	0	0					800		
7	F	0	WSW	60		75	7.4	7.2	1100	500	1023	0	0	9.0	0.4		37	900		
8	Sa	0	WSW	66		69			1100	400	942	0	0					700		
9	S	0	WSW	66		69			1100	500	980	0	0					700		
10	M	0	W	65		71	7.4	7.2	1100	500	1079	0	0	5.0	0.6		50	800		
11	T	0	WSW	72		70			1200	500	1127	0	0					800		
12	W	0	WSW	66		70			1200	500	1091	0	0					800		
13	Th	0	WSW	66		71	7.4	7.3	1200	500	1182	0	0	7.0	0.6		50	800		
14	F	0	WSW	67		71			1200	500	1257	0	0					800		
15	Sa	0	NWE	65		69			1300	500	991	0	0					700		
16	S	0	NWE	67		69	7.5	7.3	1200	500	1013	0	0	9.0	0.3		50	800		
17	M	0	WSW	74		70			1200	500	1168	0	0					800		
18	T	0	WSW	79		72			1200	500	1174	0	0					900		
19	W	0	W	74		72	7.4	7.2	1200	500	1088	0	0	8.0	0.5		50	800		
20	Th	0	WSW	65		73			1300	500	1109	0	0					900		
21	F	0	WSW	69		71			1200	500	1093	0	0					800		
22	Sa	0	WSW	78		71	7.6	7.2	1200	500	1225	0	0	10.0	0.8		37	1,000		
23	S	0	WSW	82		70			1400	500	1223	0	0					1,000		
24	M	0	W	88		70			1300	500	1200	0	0					1,000		
25	T	0	W	87		69	7.4	7.2	1300	500	1184	0	0	9.0	0.4		37	1,000		
26	W	0	W	81		71			1200	500	1239	0	0					900		
27	Th	0	WSW	79		71			1300	500	1083	0	0					800		
28																				
29																				
30																				
31																				
TOTAL																				
MAXIMUM																				
MINIMUM																				
AVERAGE																				

MONTHLY SUMMARY

SCREENINGS AND GRIT REMOVAL

60	5

SLUDGE DRAWN TO BEDS

74		

DRIED SLUDGE REMOVED

30	90

DIGESTER SURVEY

1	30	27½	8½
1	28	26	7

IMHOFF AND CLARIGESTER SURVEY

6/4/57	6½	6½
6/17/57	5	5

Date: 7/8/57
J. J. Martin
Date: 11 July 1957
Don R. Bailey

AF FORM 1462

AF Form 1462. Water Pollution Control Utility Operating Log (General)

WATER POLLUTION CONTROL PLANT OPERATING LOG --SUPPLEMENTARY

COMMAND: SAC
MONTH AND YEAR: JUNE 1957

DATE	DAY OF WEEK A	RAW SLUDGE PERCENT MOISTURE B	RAW SLUDGE PERCENT VOLATILE C	BOD RAW WASTE WATER D	BOD PRIMARY EFFLUENT E	F	G	BOD FINAL EFFLUENT H	SUSPENDED SOLIDS RAW WASTE WATER I	SUSPENDED SOLIDS PRIMARY EFFLUENT J	K	L	SUSPENDED SOLIDS FINAL EFFLUENT M	GAS PRODUCED 1000 CU. FT. N	BOILER TEMP °F O	INFLUENT TEMP °F P	EFFLUENT TEMP °F Q	DIGESTER TEMP °F R	D.O. FINAL S	PH FINAL T	U	V	W
1	S													10.0	140	71	74	97					
2	S													9.6	140	71	73	97	4.0	7.8			
3	M			120	75			45						10.1	140	70	75	97					
4	T													9.6	140	72	73	97					
5	W													9.8	140	70	72	97	5.9	7.8			
6	Th			145	70			45						10.1	140	69	71	97					
7	F													10.2	140	70	71	97					
8	S													9.8	140	70	71	97	4.8	7.6			
9	S			165	75			35						10.2	140	70	71	97					
10	M													9.7	140	71	72	97					
11	T													10.2	140	71	73	97	5.4	7.8			
12	W			105	65			25						10.9	140	69	70	97					
13	Th													10.0	140	69	71	97					
14	F													10.9	140	69	71	97	5.8	7.6			
15	S			130	65			35						10.0	140	70	72	97					
16	S													10.2	140	71	72	97					
17	M													10.3	140	71	73	97	4.4	7.8			
18	T			115	75			45						9.4	140	72	73	97					
19	W													9.2	140	71	72	97					
20	Th													9.5	140	70	71	97	6.2	7.8			
21	F			125	85			35						9.1	140	73	74	97					
22	S													9.8	140	73	75	97					
23	S													10.1	140	73	75	97	7.0	7.8			
24	M			120	80			45						10.2	140	72	74	97					
25	T													9.9	140	71	73	97					
26	W													10.3	140	71	73	87	5.0	8.6			
27	Th																						
28	F																						
29	S																						
30	S																						
31	M																						
TOTAL																							
MAXIMUM																							
MINIMUM																							
AVERAGE																							

AVERAGE PERCENT REMOVAL

UNIT	BOD	SUSPENDED SOLIDS
PRIMARY TREATMENT	43.5	
SECONDARY TREATMENT	45.9	
TOTAL	89.4	

MONTHLY DIGESTER ANALYSIS DATA 7/14/21/28

UNIT	NO 1				NO 2			
30'	97	7.6			91	7.4		
30'	97	7.4			92	7.4		
30'	97	8.0			96	7.4		
30'	97	7.6			93	7.4		

WEEKLY STREAM ANALYSIS

DATE	1. ABOVE OUTFALL 1	DO		2. BELOW OUTFALL 1	DO		3. BELOW OUTFALL 2	DO	
		PPM	% SAT		PPM	% SAT		PPM	% SAT
6/5	45	5.1		50	4.7		75	4.9	
6/17	38	4.8		40	4.9		63	5.3	
6/22	15	5.8		35	8.7		20	8.5	
6/25	22	6.1		28	6.8		37	6.5	

REMARKS

DATE: 7/8/57
SIGNATURE OF REPORTING PERSONNEL: J. Martin

DATE: 11 July 57
SIGNATURE OF BASE CIVIL ENGINEER: Don R. Bailey
Don R. Bailey, MAJ. USAF

AF FORM 1463

AF Form 1463. Water Pollution Control Utility Operating Log -- Supplementary